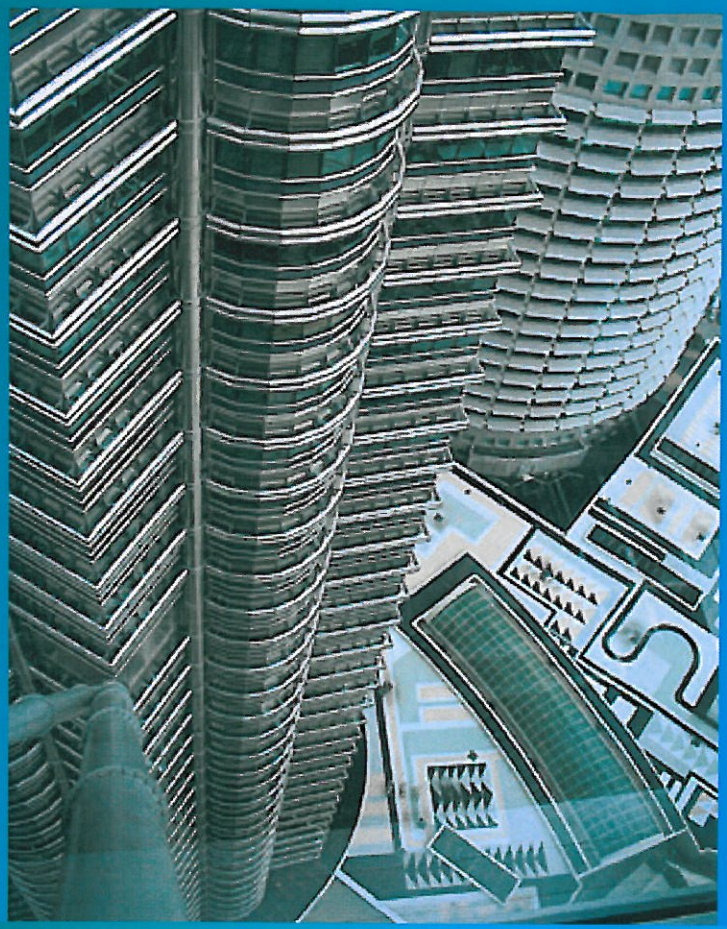
CIDB MALAYSIA

TECHNICAL OPINION

SUBMITTED TO CIDB MALAYSIA | JULY 2012

TECHNICAL OPINION REPORT



PRODUCTS

- HIGH FREQUENCY WELDED LIGHT GAUGE STEEL STRUCTURE (HFW H SECTION)
- AUTOCLAVED LIGHTWEIGHT CONCRETE PANEL (ALCP)
- BESTA BOARD PANEL

APPLICANT

WELL & ABLE (M) SDN BHD

CIDB MALAYSIA
CONSTRUCTION INDUSTRY DEVELOPMENT BOARD
7th Floor, CIDB Headquarters,
Grand Seasons Avenue,
No. 72, Jalan Pahang, 53000 Kuala Lumpur

CREAM
Construction Research Institute of Malaysia
CONSTRUCTION RESEARCH INSTITUTE OF MALAYSIA
Makmal Kerja Raya Maysia (MKRM),
IBS Centre, 1st Floor, Block E, Lot 8,
Jalan Chan Sow Lin, 55200 Kuala Lumpur

FOREWORD

Construction Industry Development Board (CIDB Malaysia) is a statutory body enacted under the Act 520 in 1994. Its mission is to develop Malaysian Construction Industry towards global competitiveness. To support that mission, a number of functions were formulated and one of them is to encourage the improvement of construction techniques and materials. Under that function, CIDB is to carry out assessment and appraisal of innovations of any kind of product and technology related to construction and to publish its finding, in the form of Technical Opinion.

This Technical Opinion will provide a reference to the relevant/interested parties in the construction industry. CIDB assess innovation based on application and evaluation by its Technical Opinion. Applicants may use it as a supporting document for regulatory and approving authorities, architects, engineers and others in dealing with the new products and technologies.

This Technical Opinion was prepared on behalf of CIDB by The Technical Expert Panel on construction products, construction materials and technologies in Construction Industry. The Technical Expert Panel was set-up by CIDB and its members were drawn from experts that represent relevant sectors in the construction industry.

This Technical Opinion has been modeled based on international recommended practice.

CIDB Technical Expert Panel Committee for :

1) **High Frequency Welded Light Gauge Steel Structure (HFW H Section)**
2) **Autoclaved Lightweight Concrete Panel (ALCP)**
3) **Besta Board Panel**

Technical Expert Panel

Ir. Dr Zuhairi Abd. Hamid	(Chairman)	CREAM
Ir. Mohd Noor Azudin Mansor	(Technical Expert Panel)	JKR MALAYSIA
Ir. Looi Hip Peu	(Technical Expert Panel)	MGBC
Prof. Dr. Rahinah Ibrahim	(Technical Expert Panel)	UPM
Assoc. Prof. Dr. Hamidah Mohd Saman	(Technical Expert Panel)	UiTM

Secretariat

Ahmad Hazim Abdul Rahim	CREAM
Mohd Termidzi Mohd Ghani	CREAM
Muhammed Asraff Abdul Rahman	CREAM
Syed Hazni Abd Gani	CREAM
Wan Norhasiah Wan Bidin	CREAM

GENERAL PROVISIONS

The purposes of this report is to assist respective parties concerned both applicant and granting approval authority, includes specification and also use of the subject. This report shall not be considered as approval.

Special note should be taken of the provisions and limitations set out and the period of validity of the Technical Opinion.

Technical Opinion is initially given a term of validity of three years from the date of issue in the expectation that, after that period, the subject will no longer be an innovation. They can be reviewed within the first twelve months and again as necessary during the life of the products or system described in the document. The limitation on the validity of the opinions should not be interpreted as implying a similarly limited life expectancy of the products or system described in the Technical Opinion. However, if experience shows poor overall standard of quality or performance, the Technical Opinion will be withdrawn.

The legitimacy and validity of the Technical Opinion can be verified at the office of CIDB Head Office.

CIDB and the Technical Expert Panels shall accept no responsibility for the quality and performance of the products.

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Disclaimer

While every effort is made to ensure accuracy of the information presented in this report, neither the Technical Expert Panels nor its Secretariats or CIDB can accept responsibility for any loss or damage incurred in connection with the use of the contents.

Definition

Technical Opinion Programme	:	A programme that initiated by CIDB with the aim to evaluate products, materials, components or system with regard to, but not limited to IBS. It normally covers wide range of innovative products to be used in local construction industry
Technical Expert Panel	:	Individual selected based on their expertise.
HFW-H Section	:	A system which is made of lightweight steel structure frame and infilled with lightweight concrete.
ALCP	:	A lightweight precast building material that simultaneously provides structure, insulation as well as resistance to mold and fire.
Besta Board Panel	:	A newly developed and upcoming green material to be used for dry construction as interior and exterior and sheathing application in construction.

Abbreviation

ALCP	Autoclaved Lightweight Concrete Panel
AS	Australian Standard
ASTM	American Standard
BS	British Standard
C	Carbon
CIDB	Construction Industrial Development Board Malaysia
Cr	Chromium
Cu	Copper
CREAM	Construction Research Institute of Malaysia
DIN	German Standard
fy	Yield Strength
GB	Chinese Standard
HFW	High Frequency Welded
IBS	Industrialised Building System
ISO	International Standards Organisation
JIS	Japanese Standard
JKR	Jabatan Kerja Raya Malaysia
MGBC	Malaysia Green Building Confederation
Mn	Manganese
Mo	Molybdenum
N	Nitrogen
Nb	Niobium
NF	France Standard
Ni	Nickel
P	Phosphorus
QA/QC	Quality Assurance / Quality Control
RC	Reinforced Concrete
S	Sulphur
Si	Silicon
SS	Singapore Standard
Ti	Titanium
UiTM	Universiti Teknologi MARA
UPM	Universiti Putra Malaysia
V	Vanadium
WASB	Well & Able (M) Sdn Bhd

Symbols

cm	centimeter
dB	decibel
g	gram
J	joule
m	meter
mm	millimeter
kg	kilogram
kN	kiloNewton
N	Newton
%	percent
°C	degree celcius

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1.0 IDENTIFICATION

1.1 Title

A. High Frequency Welded Light Gauge Steel Structure – H Section (HFW H Section)

B. Autoclaved Lightweight Concrete Panel (ALCP)

C. Besta Board Panel

1.2 Date of Evaluation

4th January 2012, 26th April 2012 and 14th June 2012

1.3 Applicant and Address

Well & Able (M) Sdn Bhd (WASB)
Box 215, Lot 3.14, 2nd Floor
Wisma Central Jalan Ampang,
50450 Kuala Lumpur, MALAYSIA
Tel : 03 2162 4623
Fax : 03 2162 4634
Email : wnamsb@gmail.com
Contact person: Mr. Wan Noordin b. Ariffin and Mr. Wong Weng Wah

Address of Factories and Warehouse:

1. High Frequency Welded Light Gauge Steel Structure
Well & Able International Pte Ltd
Room 202, No. 1 Building, No 427, Jumen Road
Shanghai 200023, PEOPLE's REPUBLIC OF CHINA
Tel : (86-21) 6146326/85/25
Fax : (86-21) 61416386
Email : wck.raymond@gmail.com
Contact person: Mr. Raymond Wong

2. Autoclaved Lightweight Concrete Panel
Well & Able International Pte Ltd
Room 202, No. 1 Building, No 427, Jumen Road
Shanghai 200023, PEOPLE's REPUBLIC OF CHINA
Tel : (86-21) 6146326/85/25
Fax : (86-21) 61416386
Email : wck.raymond@gmail.com
Contact person: Mr. Raymond Wong

3. Besta Wall & Floor Board & Panel
Well & Able International Pte Ltd
Room 202, No. 1 Building, No 427, Jumen Road
Shanghai 200023, PEOPLE's REPUBLIC OF CHINA
Tel : (86-21) 6146326/85/25
Fax : (86-21) 61416386
Email : wck.raymond@gmail.com
Contact person: Mr. Raymond Wong

4. Warehouse in Malaysia
Well & Able (M) Sdn Bhd
C/o Distrepark Logistic Sdn. Bhd
Corporate Office : B-8-2, Tower B,
BBT One, Lebuh Batu Nilam 1.
Bandar Bukit Tinggi, 41200 Klang, Selangor.
MALAYSIA
Tel : (603) 3167 9331
Fax: (603) 3168 4886
Contact person: Mr. How Kok

Note:

This Technical Opinion report is issued based on application and documents provided by Well & Able (M) Sdn Bhd (WASB) and only valid for the product specification rendered during submission. It is the responsibility of the applicant to notify CIDB of any change in the product specification and supplier mentioned in this report.

2.0 PRODUCT

2.1 Product Evaluation

The applicant had submitted three (3) products to be evaluated. The products are :

i. High Frequency Welded Light Gauge Steel Structure – H Section (HFW H Section)
ii. Autoclaved Lightweight Concrete Panel (ALCP)
iii. Besta Board Panel

The evaluations for each product are reported in these parts which are Part A, Part B and Part C that represent HFW H Section, ALCP and Besta Board Panel respectively. The following sections will entail each part.

3.0 PART A

HIGH FREQUENCY WELDED LIGHT GAUGE STEEL STRUCTURE – H SECTION (HFW H SECTION)

3.1 DESCRIPTION

3.1.1 General Description of the Product

HFW H Section is a system which is made of lightweight steel structure frame and infilled with lightweight concrete. The lightweight steel structure constitutes a framing member and it is made from a steel sheet that applied with a layer of zinc coating. The sections of the system are welded using high frequency welding i.e electron beam welding. HFW H Section is a system that is innovated to facilitate the construction of buildings.

High Frequency Welding is a part of group process in the Fusion Welding which it bonds metal together by heating a portion of each piece above their melting temperature causing them to fuse together. For this HFW H section, the light gauge steel is used and electron beam fuses the light gauge steel. This process uses high-velocity electrons that are targeted to the weld joints. Upon impact of the electron to the materials, it generates the required heat input to create a fuse weld.

All materials that constitute the in HFW H Section are imported from China

3.1.2 Usage and Application of the Product

HFW H Section can be used as main structural columns and beams (e.g: for residential houses) or as the secondary structural members for the large building. The product usage for this product is shown in Appendix A1.

Due to the method of production, the H-beam is fully customizable and can be tailored made to fit any type of construction project. Engineer will be able to design according to their specific requirement and not limited by the standard hot roll H beam sizes. It is claimed that as such it enhances efficiency and reduces cost significantly.

3.1.3 Element of the Product

The sections to form HFW H Section are made of silted steel. The disintegral parts that constitute the H-Section are welded together using high frequency welding as explained in Section 3.1.1

3.1.4 Usage Limitation

The main column that made of HFW H Section can only be erected up to twenty (20) storeys only.

3.1.5 Manufacturing Process

High frequency welding is a technique or technology where three strips of hot or cold roll steel are continuously welded together using high frequency welding technique. It is a part of the group of process in the Fusion Welding, in which it bonds metal together by heating a portion of each piece above their melting point causing them to fuse together. The details of the manufacturing process of the HFW H Section are shown in Appendix A2.

3.1.6 Equipment and Skill Required

For site installation, only simple hand tools, minimum lightweight hoisting equipments and semi- skilled workers are required. For the connection, the full bolt and nuts are the steel connectors.

3.2 BASIS OF APPRAISAL

3.2.1 Document Received from Well & Able (M) Sdn Bhd (WASB)

The following documents were received to support the appraisal of the product.

i. Documents on the details and description of the product.

ii. Test report on the material and product

3.2.2 Technical Visit to Site

No technical visit to site has been made.

3.3 MATERIAL: SPECIFICATIONS AND TESTS

3.3.1 Specifications

i. Product range

HFW H Section can be customized with minimum cross section 50mm x 50mm up to maximum section of 500 mm x 300 mm. The thickness also can be customized from a minimum of 2.0 mm to 10 mm. The product range of HFW H Section and manufacturing tolerance are attached in Appendix A3.

ii. Chemical composition

The chemical composition of the silted steel used for HFW H Section is shown in Table 1.

Table 1: Chemical composition of the silted steel

Standard	Serial No.	Chemical Composition				
		C	Si	Mn	P	S
GB/T1591 JISG3106	Q345 (16 Mn)	0.12-0.02	0.20-0.55	0.2 - 01.60	≤ 0.045	
	SM490YA	≤ 0.20	≤ 0.55	≤ 1.60	≤ 0.035	≤ 0.035
	SM490YB					

iii. Mechanical properties

The mechanical properties of the silted steel used for HFW H Section are shown in Table 2.

Table 2: Mechanical properties of the silted steel

Serial No.	Thickness (mm)	Tensile Strength (N/mm^2)	Mim. Yield Strength (N/mm^2)	Elongation %	Bending test 180	V-Impact Testing	
					Bending diameter, d / Testing thickness, a	Testing temperature (°C)	Joule (J)
Q345 (16 Mn)	≤ 16	510-660	≥ 345	≥ 22	d=2a	-	-
	> 16~25	490-640	≥ 325	≥ 21	d=3a	20	≥ 27
	>25~36	470-620	≥ 315		d=3a	0	
SM490 YA	≤ 16	490-610	365	≥ 19	-	-	-
SM490 YB	> 16~40		355		-	0	27

3.3.2 Types of Testing

The following tests have been done on the product in accordance with acceptable International Standards.

i. Test on material (steel plate)

a. Reduced Section Tensile Test

b. 'V'-Notch Charpy Impact Test

c. Chemical Composition

ii. Test on product (HFW H section)

a. Reduced Section Tensile Test

b. 'V'-Notch Charpy Impact Test

c. Chemical Composition

However, these tests were not carried out by the request of the Applicant, instead they were requested by other parties related to the Applicant (please refer Section 10.1).

3.3.3 Additional Tests Required

The Applicant is to notify to the Technical Expert Panel on any additional test required (if any) by the fabricator or client.

3.3.4 Check on Test Report Provided by WASB

i. Test on material

The tests that have been performed on the material of the product are as follows:

a. Reduced Section Tensile Test

b. 'V'-Notch Charpy Impact Test

c. Chemical Composition

The summary of the tests done, the specifications and results are shown in Table 3. The official test reports are attached in Appendix A4:a.

Table 3 : The summary of the tests done, the specification for material and results

Type of test	Result
Structural Steel Test (Steel Plate) (Dated : 23rd December 2011) *(for official test report, please refer to Appendix A4 : a (page 19- page 33)*	
Reduced Section Tensile Test The tested samples shall met the requirements of Grade Q345B GB/T 1591:2008 specification.	Please refer to official test report for detail results (Appendix A: page 21 – 24) (Method of Test : GB/T 228:2002)
'V'-Notch Charpy Impact Test The tested samples shall met the requirements of Grade Q345B GB/T 1591:2008 specification.	Please refer to official test report for detail results (Appendix A : page 25 – 28) (Method of Test : GB/T 229:2007)
Chemical Composition The tested samples shall met the requirements of Grade Q345B GB/T 1591:2008 specification.	Please refer to official test report for detail results (Appendix A : page 29 – 33) (Method of Test : ASTM E 415:2008)

ii. Test on product

The tests that have been performed on this product are as follows :

a. Reduced Section Tensile Test

b. 'V'-Notch Charpy Impact Test

c. Chemical Composition

The summary of the tests done, the specifications and the results are shown in Table 4. The official test reports are attached in Appendix A4:b.

Table 4 : The summary of the tests done, the specifications for material and results

Type of test	Result
Structural Steel Test (H Beam) (Dated : 23rd December 2011) *(for official test report, please refer to Appendix A4 : b (page 34- page - 43)*	
Reduced Section Tensile Test The tested samples shall met the requirements of Grade Q345B GB/T 1591:2008 specification.	Please refer to official test report for detail results (Appendix A : page 36 – 37) (Method of Test : GB/T 228:2002)
'V'-Notch Charpy Impact Test The tested samples shall met the requirements of Grade Q345B GB/T 1591:2008 specification.	Please refer to official test report for detail results (Appendix A : page 38 – 40) (Method of Test : GB/T 229:2007)
Chemical Composition The tested samples shall met the requirements of Grade Q345B GB/T 1591:2008 specification.	Please refer to official test report for detail results (Appendix A : page 41 – 43) (Method of Test : ASTM E 415:2008)

3.4 COMPLIANCE TO INTERNATIONAL STANDARDS OR EQUIVALENT

i. Raw material

The material used for manufacturing the HFW H Section is silted steel and it is in accordance with some International Standard from various countries. The equivalent International Standards of steel for various countries are listed in Table 5.

Table 5 : Equivalent standards of silted steel in various countries

Raw Material	**Standard** *(Reference provided by WASB)*	**Other Equivalent and Resemblance Standards**[1,2] *(See Note 1 and 2)*
Silted steel	**GB Q235B** Standard for Hot Rolled Carbon Structural Steel Plate	**ASTM A36/A36M – 00** Standard Specifications for Carbon Structural Steel **ASTM A572/A572M – 00** Standard Specifications for High Strength Low-Alloy Columbium-Vanadium Structural Steel
		JIS G3101:2004 Rolled Steels for General Structure **JIS G3106:2008** Rolled Steels for Welded Structure
		DIN 17100 Rst37-2 Steels for General Purposes (Resemblance standard) **DIN St52-3** *Note :The Secretariat cannot establish the name of the standard*
		NF E24-2NE *Note :The Secretariat cannot establish the name of the standard*

[1]*Note 1 : The equivalent and resemblance standards are based from internet search and book references by the Secretariat.*

[2]*Note 2 : The Technical Expert Panels cannot established acceptable range specify in other equivalent and resemblance standards as this was not part of the terms of reference required*

ii. HFW H Section test

For the test report, the test done adopted only a few equivalent and resemblance standards. The standards used for test on material and test on product are the same. The standards adopted are shown in Table 6.

Table 6 : Type of tests and standards adopted

Type of Test	**Standard** *(Reference provided by WASB)*	**Other Equivalent and Resemblance Standards**[1,2] *(See Note 1 and 2)*
'V'-Notch Charpy Impact Test	**GB/T 229:2007** Charpy Notch Impact Test Method for Metal Material	**ISO 148-1:2009** Metallic materials - Charpy pendulum impact test - Part 1: Test method **ASTM E23** Standard Test Methods for Notched Bar Impact Testing of Metallic Materials
Reduced Section Tensile Test	**GB/T228:2002** Method for Tensile Test of Metallic Materials at Room Temperature	**ISO 6892-1-2009** Metallic materials-Tensile testing - Part 1: Method of test at room temperature
Chemical Composition	**ASTM E415:2008** Standard Test Method for Atomic Emission Vacuum Spectrometric Analysis of Carbon and Low-Alloy Steel	

[1]*Note 1 : The equivalent and resemblance standards are based from internet search by the Secretariat.*

[2]*Note 2 : The Technical Expert Panels cannot established acceptable range specify in other equivalent and resemblance standards as this was not part of the terms of reference required*

3.5 APPENDIX A

A1 : HFW H SECTION PRODUCT USAGE

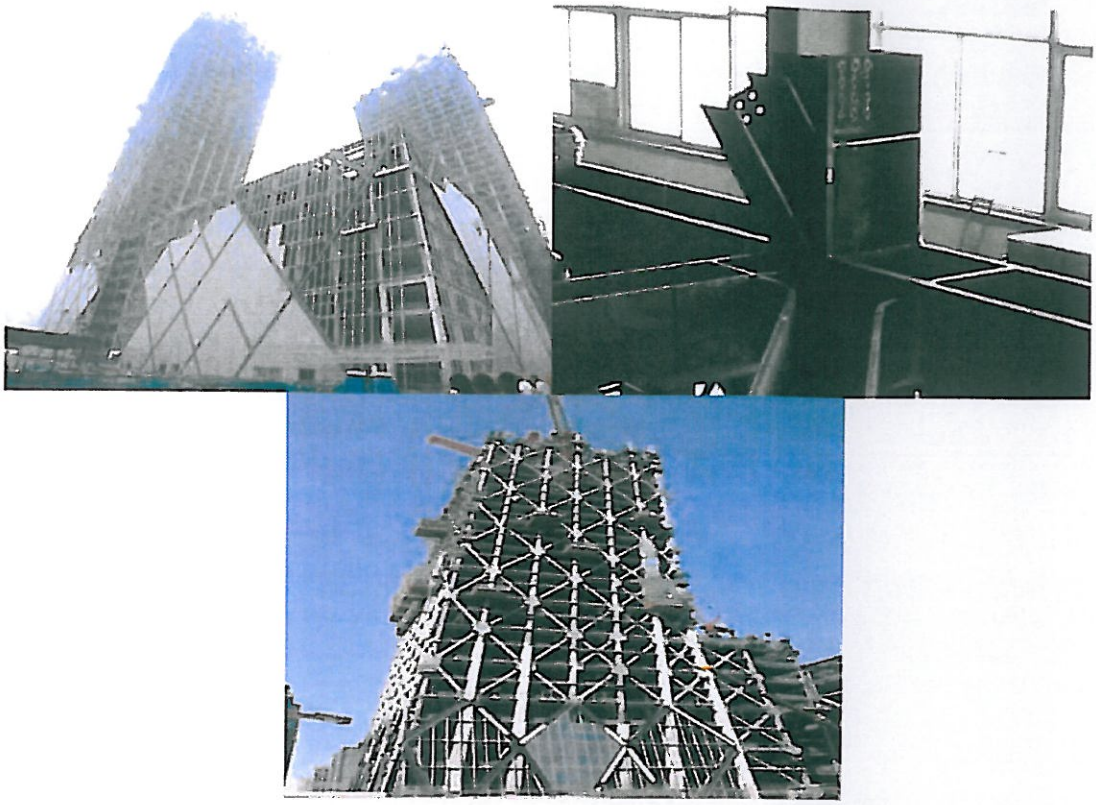


Figure 1 : HFW H Sections are widely used for secondary structure for large building.

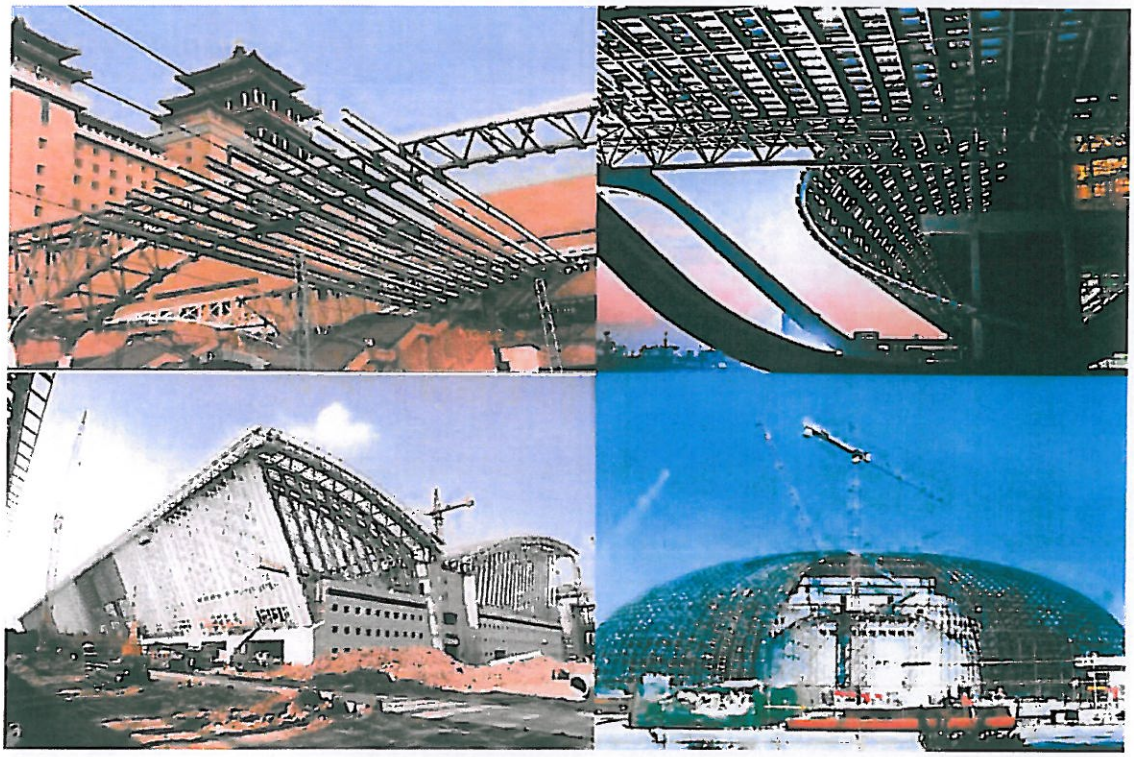


Figure 2 : HFW H Sections are widely used as main columns and beams for residential building

Figure 3 : HFW H Section used as main columns and beams for residential building and other application

A2 : MANUFACTURING PROCESS OF HFW H SECTION

Figure 4: Special silted steel coil designed to the required thickness and width before being fed into the production line

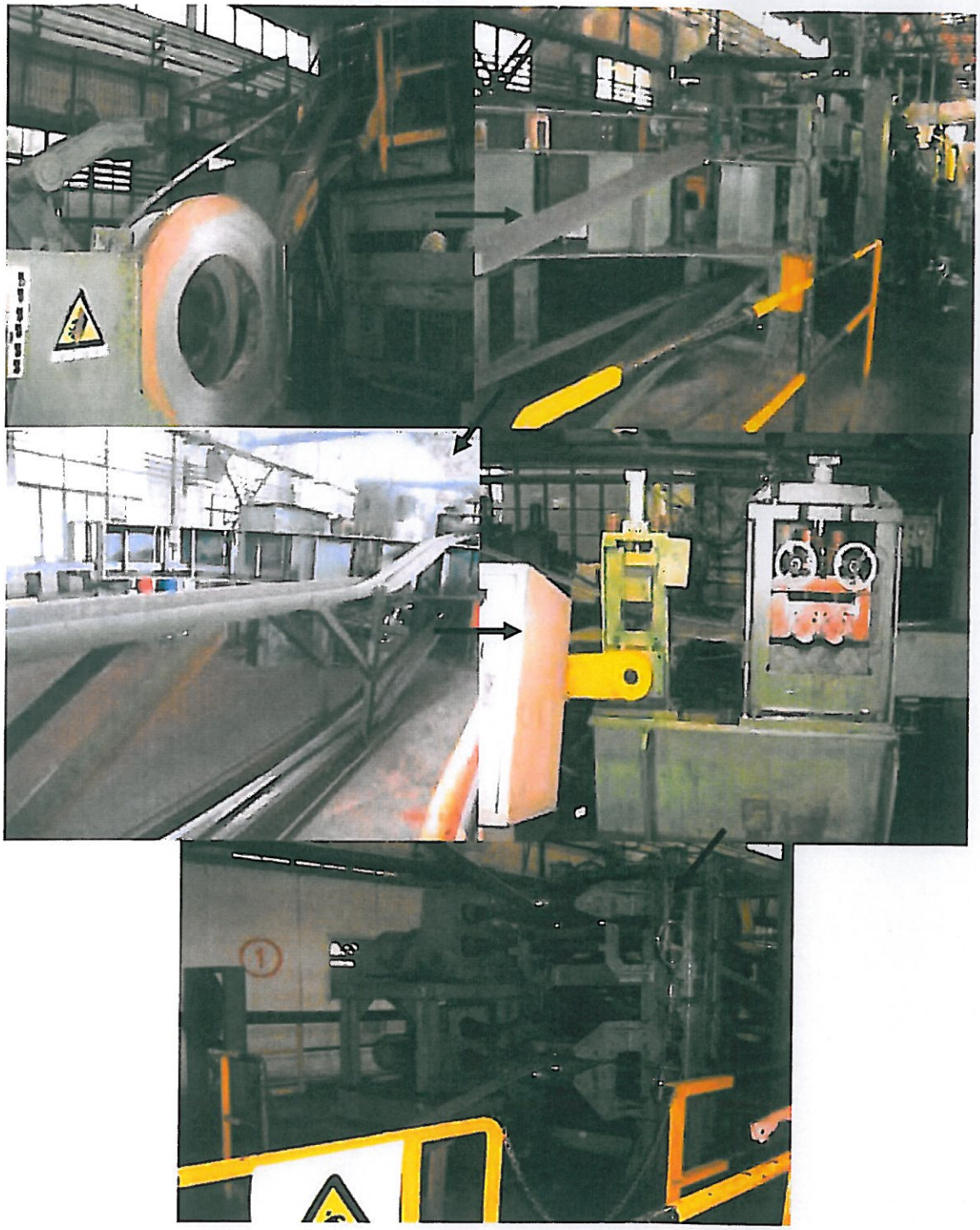


Figure 5 :The uncoiled steel rolls are processed into three pre –straightened steel strips before entered into “Patented” welded hea for high frequency welding

Figure 6 : Three steel strips welded by our high frequency welding process

Figure 7 : After the stress relieve and strengthening of the welded H section, it will be cut to the desired length

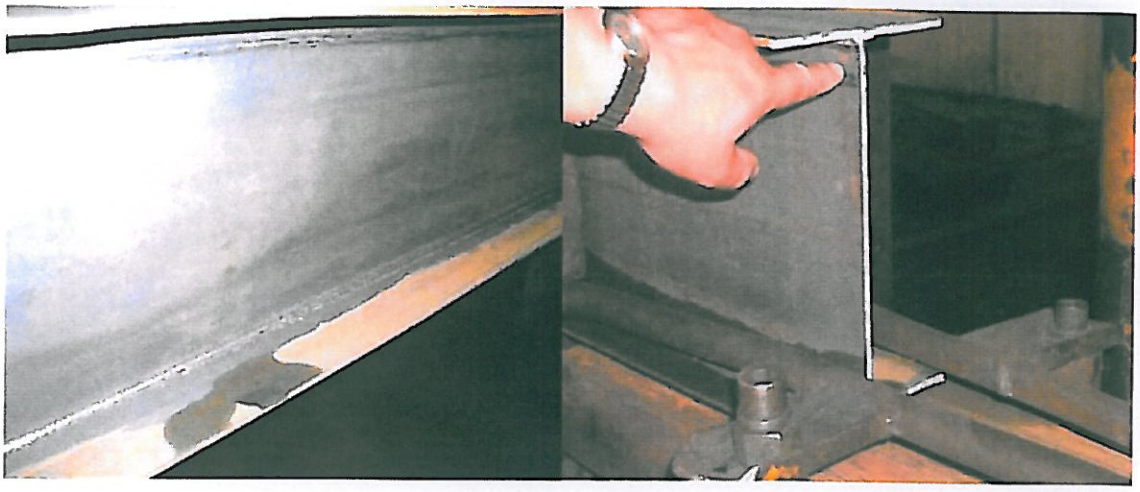


Figure 8 : Quality inspection are conducted onsite

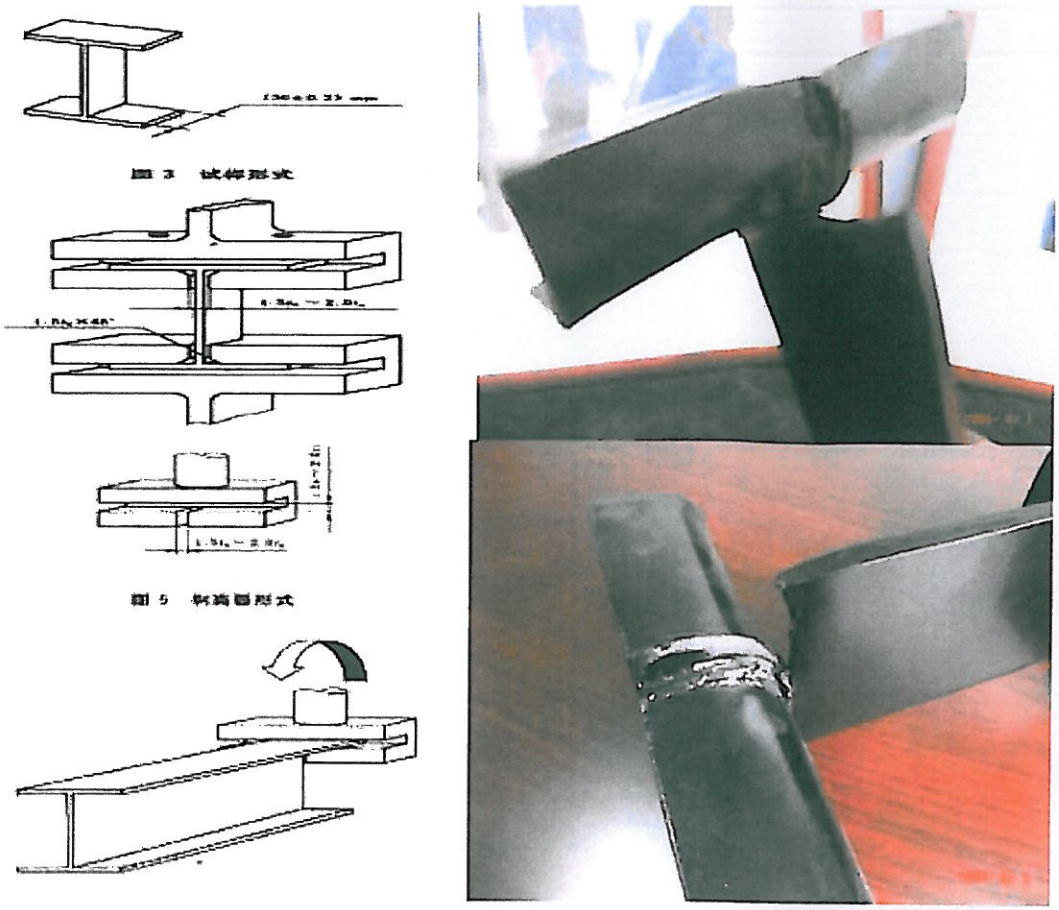
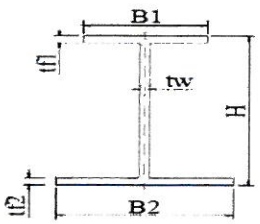


Figure 9 : Every batches that are produced will go through the pull-up test onsite

A3 : PRODUCT RANGE OF HFW H SECTION AND MANUFACTURING TOLERANCE

a) **Product Range of HFW H Section**

Un-Equal Flange cross section



H－高度
Height

B1－上翼缘宽度
Width of Upper Flange

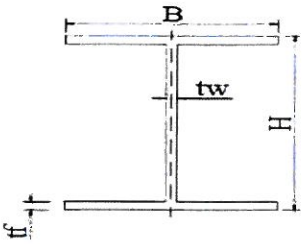
B2－下翼缘宽度
Width of Lower Flange

tw－腹板厚度
Thickness of Web

tf1－上翼缘厚度
Thickness of Upper Flange

tf2－下翼缘厚度
Thickness of Lower Flange

Equal Flange cross section



H－高度
Height

B－宽度
Width

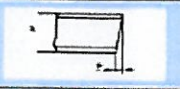
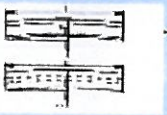
tw－腹板厚度
Thickness of Web

tf－翼缘厚度
Thickness of Lower Flange

H	高度	Height	Min	60mm	Max	500mm
B	宽度	Width	Min	50mm	Max	250mm
tw	腹板厚度	Thickness of Web	Min	2.2mm	Max	8.0mm
tf	翼缘厚度	Thickness of Flange	Min	2.3mm	Max	10.0mm

b) Manufacturing Tolerance

Dimension, Shapes & Tolerances

项目 Item		允许偏差 Allowable Tolerance		图示 Legend
腹板偏心度(S) $S=\|b_1-b_2\|/2$ Eccentricity of Web		2.0mm		
端面切斜度(e) Shearing slant of ends		H>200mm H≤200mm	5.0mm 3.0mm	
弯曲度（c） Bending	H≤300mm H>300mm	Lx0.20% Lx0.10%		

A4 : TEST REPORT ON HFW H SECTION PRODUCT

a) Test report on Steel Plate Test (Material)

SETSCO SERVICES PTE LTD
18 Teban Gardens Crescent
Singapore 608925
Tel : (65) 6566 7777
Fax: (65) 6566 7718
Website: www.setsco.com
Business Reg. No. 196900269D

TEST REPORT

(This Report is issued subject to the terms & conditions set out below)

Your Ref: - Our Ref: MM-25054/1-12/YPS Date: 28 December 2011

Subject : Testing of structural steel submitted by Greenfab Pte Ltd on 22 December 2011.

Tested For : **KOON SENG CONSTRUCTION PTE LTD**
Fu Lu Shou Complex,
149 Rochor Road,
#05-02 Singapore 188425

Attn: Mr. Albert Goh

Consultant : **LSW CONSULTING ENGINEERS PTE LTD**
Blk 261 Waterloo St #04-08
Singapore 180261

Attn: Ms. Shirley Tan / Ms. Jacelyn Lim

Subcontractor :
1) **GREENFAB PTE LTD**
Blk 8 Jalan Kukoh
#01-33
Singapore 162008

Attn: Mr. Patrick Woo

2) **WELL & ABLE INTERNATIONAL PTE LTD**
103 Defu Lane 10
#02-03 BTH Building
Singapore 539223

Attn: Mr. Raymond Wong

Project : Proposed Erection of a 4-Storey Factory Comprises of 3-Storey Production Areas and 1-Storey of Ancillary Dormitory on Lot 0653W, MK11 at 2 Sungei Kadut Loop, Singapore 729449.

ReportsOthers2011/stphy

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SETSCC

Date and Place of Test : 23 December 2011 at Setsco Laboratory

Method of Test : GB/T 1591 : 2008 - Reduced Section Tensile Test (GB/T 228: 2002)
- 'V'-Notch Charpy Impact Test (GB/T 229: 2007)
- Chemical Composition (ASTM E 415: 2008)

Description of Sample : Eleven (11) pieces of structural steel said to be Grade Q345B material were received. The specimens submitted were sampled at Shanghai Xiazhou Marine Machinery Equipment Co. Ltd.

S/No.	Sample Ref.	Sample Marking	Heat No.	Qty
1	Steel Plate 8mm thk	S1	1034768	01
2	Steel Plate 10mm thk	S2	91132007	01
3	Steel Plate 12mm thk	S3	1023924	01
4	Steel Plate 14mm thk	S4-1	91128946	01
5	Steel Plate 14mm thk	S4-2	91128944	01
6	Steel Plate 16mm thk	S5-1	1031335	01
7	Steel Plate 16mm thk	S5-2	1031331	01
8	Steel Plate 18mm thk	S6	1033192141092933	01
9	Steel Plate 20mm thk	S7	0903252	01
10	Steel Plate 25mm thk	S8	1109-6113	01
11	Steel Plate 40mm thk	S9	-	01

Results :

1) Reduced Section Tensile Test
The tested samples met the requirements of Grade Q345B GB/T 1591: 2008 specification. Refer to Table 1 attached.

2) 'V'-Notch Charpy Impact Test
The tested samples met the requirements of Grade Q345B GB/T 1591: 2008 specification. Refer to Table 2 attached.

3) Chemical Composition
The tested samples met the requirements of Grade Q345B GB/T 1591: 2008 specification. Refer to Table 3 attached.

YAP PA SUN
Testing Officer

CHENG KWANG MENG
Manager (Mechanical Testing)
Mechanical Technology Division

Results:

Table 1a: Reduced Section Tensile Test

Sample Reference	Steel Plate 8mm thk Sample : S1	Steel Plate 10mm thk Sample : S2	Steel Plate 12mm thk Sample : S3	Steel Plate 14mm thk Sample : S4-1	GB/T 1591 : 1994 Grade Q345B ≤ 16 mm thk Requirements
Measured Mean Width (mm)	20.08	20.05	20.06	20.13	-
Measured Mean Thickness (mm)	7.86	10.00	11.97	13.90	-
Cross-sectional Area, So (mm²)	157.83	200.50	240.12	279.81	-
Yield Load (kN)	60.9	72.4	86.4	102.4	-
Yield Stress (N/mm²)	385.9	361.1	359.8	366.0	Min. 345
Maximum Load (kN)	84.7	103.1	122.8	147.9	-
Tensile Strength (N/mm²)	536.7	514.2	511.4	528.6	Min. 470 Max. 630
Elongation on 80 mm Gauge Length (%)	26	29	29	29	-
Converted Elongation on 5.65 √So Gauge Length (%)	27	29	28	27	Min. 20
Position of Fracture	Fractured within gauge mark.				-

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Results:

Table 1b: Reduced Section Tensile Test

Sample Reference	Steel Plate 14mm thk Sample : S4-2	Steel Plate 16mm thk Sample : S5-1	Steel Plate 16mm thk Sample : S5-2	GB/T 1591 : 1994 Grade Q345B ≤ 16 mm thk Requirements
Measured Mean Width (mm)	20.06	20.10	20.09	-
Measured Mean Thickness (mm)	13.91	15.56	15.54	-
Cross-sectional Area, So (mm^2)	279.03	312.76	312.20	-
Yield Load (kN)	102.5	116.6	119.3	-
Yield Stress (N/mm^2)	367.3	372.8	382.1	Min. 345
Maximum Load (kN)	146.9	162.8	161.8	-
Tensile Strength (N/mm^2)	526.5	520.5	518.3	Min. 470 Max. 630
Elongation on 80 mm Gauge Length (%)	32	34	33	-
Converted Elongation on 5.65 √So Gauge Length (%)	30	31	30	Min. 20
Position of Fracture	Fractured within gauge mark.			-

SETSCO

Results:

Table 1c: Reduced Section Tensile Test

Sample Reference	Steel Plate18mm thk Sample : S6	Steel Plate 20mm thk Sample : S7	GB/T 1591 : 1994 Grade Q345B >16 to 40 mm thk Requirements
Measured Mean Width (mm)	20.09	20.04	-
Measured Mean Thickness (mm)	17.71	20.20	-
Cross-sectional Area, So (mm^2)	355.79	404.81	-
Yield Load (kN)	140.1	150.9	-
Yield Stress (N/mm^2)	393.8	372.8	Min. 335
Maximum Load (kN)	193.3	208.2	-
Tensile Strength (N/mm^2)	543.3	514.3	Min. 470 Max. 630
Elongation on 80 mm Gauge Length (%)	31	34	-
Converted Elongation on 5.65 √So Gauge Length (%)	28	37	Min. 20
Position of Fracture	Fractured within gauge mark.		-

SETSCO

Results:

Table 1d: Reduced Section Tensile Test

Sample Reference	Steel Plate 25mm thk Sample : S8	Steel Plate 40mm thk Sample : S9	GB/T 1591 : 1994 Grade Q345B >16 to 40 mm thk Requirements
Measured Mean Diameter (mm)	20.02	20.07	-
Cross-sectional Area, So (mm^2)	314.79	314.47	-
Yield Load (kN)	108.8	115.8	-
Yield Stress (N/mm^2)	345.6	368.2	Min. 335
Maximum Load (kN)	165.4	169.9	-
Tensile Strength (N/mm^2)	525.4	540.3	Min. 470 Max. 630
Elongation on 100 mm Gauge Length (%)	29	29	Min. 20
Position of Fracture	Fractured within gauge mark.		-

SETSCO

Results:

Table 2a: 'V'-Notch Charpy Impact Test

Sample Reference	Item Measured	Dimension of Test Specimen	Impact Value at +20°C (Joules)	GB/T1591-2008 Grade Q345B Requirement
Steel Plate 8mm thk Sample : S1	Test 1	10 x 7.5 x 55 mm	40	-
	Test 2		38	
	Test 3		38	
	Average		39	Min. 25.5 (J)

Table 2b: 'V'-Notch Charpy Impact Test

Sample Reference	Item Measured	Dimension of Test Specimen	Impact Value at +20°C (Joules)	GB/T1591-2008 Grade Q345B Requirement
Steel Plate 10mm thk Sample : S2	Test 1	10 x 7.5 x 55 mm	46	-
	Test 2		46	
	Test 3		48	
	Average		47	Min. 25.5 (J)

Table 2c: 'V'-Notch Charpy Impact Test

Sample Reference	Item Measured	Dimension of Test Specimen	Impact Value at +20°C (Joules)	GB/T1591-2008 Grade Q345B Requirement
Steel Plate 12mm thk Sample : S3	Test 1	10 x 10 x 55 mm	82	-
	Test 2		88	
	Test 3		90	
	Average		87	Min. 34 (J)

SETSCO

Results:

Table 2d: 'V'-Notch Charpy Impact Test

Sample Reference	Item Measured	Dimension of Test Specimen	Impact Value at +20°C (Joules)	GB/T1591-2008 Grade Q345B Requirement
Steel Plate 14mm thk Sample : S4-1	Test 1	10 x 10 x 55 mm	94	-
	Test 2		110	
	Test 3		96	
	Average		100	Min. 34 (J)

Table 2e: 'V'-Notch Charpy Impact Test

Sample Reference	Item Measured	Dimension of Test Specimen	Impact Value at +20°C (Joules)	GB/T1591-2008 Grade Q345B Requirement
Steel Plate 14mm thk Sample : S4-2	Test 1	10 x 10 x 55 mm	86	-
	Test 2		96	
	Test 3		100	
	Average		94	Min. 34 (J)

Table 2f: 'V'-Notch Charpy Impact Test

Sample Reference	Item Measured	Dimension of Test Specimen	Impact Value at +20°C (Joules)	GB/T1591-2008 Grade Q345B Requirement
Steel Plate 16mm thk Sample : S5-1	Test 1	10 x 10 x 55 mm	84	-
	Test 2		82	
	Test 3		86	
	Average		84	Min. 34 (J)

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Results:

Table 2g: 'V'-Notch Charpy Impact Test

Sample Reference	Item Measured	Dimension of Test Specimen	Impact Value at +20°C (Joules)	GB/T1591-2008 Grade Q345B Requirement
Steel Plate 16mm thk Sample : S5-2	Test 1	10 x 10 x 55 mm	78	-
	Test 2		80	
	Test 3		80	
	Average		79	Min. 34 (J)

Table 2h: 'V'-Notch Charpy Impact Test

Sample Reference	Item Measured	Dimension of Test Specimen	Impact Value at +20°C (Joules)	GB/T1591-2008 Grade Q345B Requirement
Steel Plate18mm thk Sample : S6	Test 1	10 x 10 x 55 mm	64	-
	Test 2		68	
	Test 3		68	
	Average		67	Min. 34 (J)

Table 2i: 'V'-Notch Charpy Impact Test

Sample Reference	Item Measured	Dimension of Test Specimen	Impact Value at +20°C (Joules)	GB/T1591-2008 Grade Q345B Requirement
Steel Plate 20mm thk Sample : S7	Test 1	10 x 10 x 55 mm	126	-
	Test 2		140	
	Test 3		144	
	Average		137	Min. 34 (J)

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Results:

Table 2j: 'V'-Notch Charpy Impact Test

Sample Reference	Item Measured	Dimension of Test Specimen	Impact Value at +20°C (Joules)	GB/T1591-2008 Grade Q345B Requirement
Steel Plate 25mm thk Sample : S8	Test 1	10 x 10 x 55 mm	240	-
	Test 2		232	
	Test 3		UB	
	Average		-	Min. 34 (J)

'UB' – Unbroken at 300J

Table 2k: 'V'-Notch Charpy Impact Test

Sample Reference	Item Measured	Dimension of Test Specimen	Impact Value at +20°C (Joules)	GB/T1591-2008 Grade Q345B Requirement
Steel Plate 40mm thk Sample : S9	Test 1	10 x 10 x 55 mm	204	-
	Test 2		216	
	Test 3		198	
	Average		206	Min. 34 (J)

Results:

Table 3a: Chemical Composition

Sample Reference / Element	Steel Plate 8mm thk Sample : S1	Steel Plate 10mm thk Sample : S2	Steel Plate 12mm thk Sample : S3	GB/T1591-2008 Grade Q345B Requirements	BC1: 2008 (BS EN 10025-2: 2004) Grade S355JR Requirements
Carbon, C (%)	0.17	0.19	0.16	Max. 0.27	Max. 0.27
Silicon, Si (%)	0.32	0.34	0.29	Max. 0.60	Max. 0.60
Manganese, Mn (%)	1.30	0.88	1.25	Max. 1.70	Max. 1.70
Phosphorous, P (%)	0.026	0.021	0.025	Max. 0.050	Max. 0.045
Sulphur, S (%)	0.025	0.013	0.013	Max. 0.050	Max. 0.045
Niobium, Nb (%)	0.001	0.0004	0.0003	Max. 0.07	-
Vanadium, V (%)	0.006	0.002	0.009	Max. 0.15	-
Titanium, Tl (%)	0.003	0.001	0.003	Max. 0.20	-
Chromium, Cr (%)	0.023	0.021	0.027	Max. 0.30	-
Nickel, Ni (%)	0.013	0.014	0.010	Max. 0.50	Max. 0.60
Copper, Cu (%)	0.013	0.072	0.021	Max. 0.30	-
Nitrogen, N (%)	0.001	0.002	0.003	Max. 0.012	-
Molybdenum, Mo (%)	0.001	0.002	0.001	Max. 0.10	-
Carbon Equivalent Value, CEV (%)	0.39	0.35	0.38	Max. 0.44	Max. 0.53

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Results:

Table 3b: Chemical Composition

Sample Reference / Element	Steel Plate 14mm thk Sample : S4-1	Steel Plate 14mm thk Sample : S4-2	Steel Plate 16mm thk Sample : S5-1	GB/T1591-2008 Grade Q345B Requirements	BC1: 2008 (BS EN 10025-2: 2004) Grade S355JR Requirements
Carbon, C (%)	0.19	0.19	0.15	Max. 0.27	Max. 0.27
Silicon, Si (%)	0.36	0.36	0.36	Max. 0.60	Max. 0.60
Manganese, Mn (%)	0.89	0.91	1.29	Max. 1.70	Max. 1.70
Phosphorous, P (%)	0.028	0.028	0.018	Max. 0.050	Max. 0.045
Sulphur, S (%)	0.011	0.010	0.018	Max. 0.050	Max. 0.045
Niobium, Nb (%)	0.0004	0.0004	0.0004	Max. 0.07	-
Vanadium, V (%)	0.003	0.003	0.004	Max. 0.15	-
Titanium, TI (%)	0.002	0.002	0.003	Max. 0.20	-
Chromium, Cr (%)	0.020	0.020	0.030	Max. 0.30	-
Nickel, Ni (%)	0.014	0.014	0.010	Max. 0.50	Max. 0.60
Copper, Cu (%)	0.068	0.070	0.015	Max. 0.30	-
Nitrogen, N (%)	0.001	0.001	0.002	Max. 0.012	-
Molybdenum, Mo (%)	0.002	0.002	0.001	Max. 0.10	-
Carbon Equivalent Value, CEV (%)	0.35	0.35	0.38	Max. 0.44	Max. 0.53

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Results:

Table 3c: Chemical Composition

Sample Reference / Element	Steel Plate 16mm thk Sample : S5-2	Steel Plate 18mm thk Sample : S6	Steel Plate 20mm thk Sample : S7	GB/T1591-2008 Grade Q345B Requirements	BC1: 2008 (BS EN 10025-2: 2004) Grade S355JR Requirements
Carbon, C (%)	0.15	0.15	0.15	Max. 0.27	Max. 0.27
Silicon, Si (%)	0.35	0.36	0.33	Max. 0.60	Max. 0.60
Manganese, Mn (%)	1.27	1.30	1.26	Max. 1.70	Max. 1.70
Phosphorous, P (%)	0.016	0.022	0.022	Max. 0.050	Max. 0.045
Sulphur, S (%)	0.018	0.016	0.008	Max. 0.050	Max. 0.045
Niobium, Nb (%)	0.0002	0.001	0.001	Max. 0.07	-
Vanadium, V (%)	0.003	0.005	0.004	Max. 0.15	-
Titanium, Tl (%)	0.002	0.003	0.003	Max. 0.20	-
Chromium, Cr (%)	0.026	0.024	0.033	Max. 0.30	-
Nickel, Ni (%)	0.010	0.010	0.011	Max. 0.50	Max. 0.60
Copper, Cu (%)	0.015	0.016	0.033	Max. 0.30	-
Nitrogen, N (%)	0.001	0.001	0.002	Max. 0.012	-
Molybdenum, Mo (%)	0.001	0.001	0.002	Max. 0.10	-
Carbon Equivalent Value, CEV (%)	0.37	0.37	0.37	Max. 0.44	Max. 0.53

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Results:

Table 3d: Chemical Composition

Sample Reference / Element	Steel Plate 25mm thk Sample : S8	Steel Plate 40mm thk Sample : S9	GB/T1591-2008 Grade Q345B Requirements	BC1: 2008 (BS EN 10025-2: 2004) Grade S355JR Requirements
Carbon, C (%)	0.16	0.16	Max. 0.27	Max. 0.27
Silicon, Si (%)	0.28	0.30	Max. 0.60	Max. 0.60
Manganese, Mn (%)	1.38	0.42	Max. 1.70	Max. 1.70
Phosphorous, P (%)	0.018	0.018	Max. 0.050	Max. 0.045
Sulphur, S (%)	0.004	0.004	Max. 0.050	Max. 0.045
Niobium, Nb (%)	0.001	0.034	Max. 0.07	-
Vanadium, V (%)	0.002	0.004	Max. 0.15	-
Titanium, Tl (%)	0.017	0.018	Max. 0.20	-
Chromium, Cr (%)	0.036	0.034	Max. 0.30	-
Nickel, Ni (%)	0.022	0.018	Max. 0.50	Max. 0.60
Copper, Cu (%)	0.061	0.031	Max. 0.30	-
Nitrogen, N (%)	0.001	0.003	Max. 0.012	-
Molybdenum, Mo (%)	0.004	0.004	Max. 0.10	-
Carbon Equivalent Value, CEV (%)	0.41	0.24	Max. 0.44	Max. 0.53

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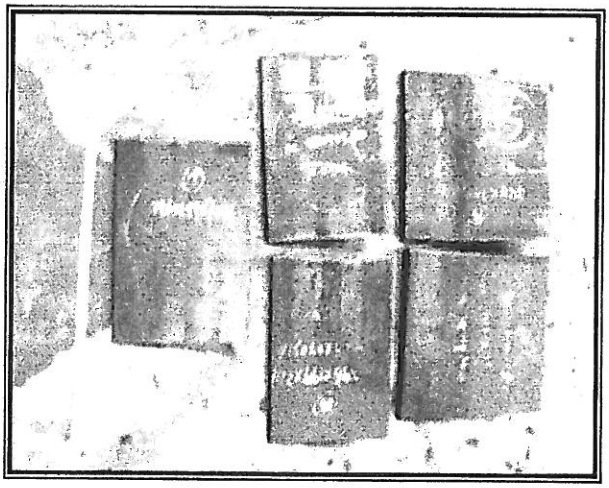
Appendix:



Photographs show samples submitted.

b) Test report on structural steel

SETSCO SERVICES PTE LTD
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Business Reg. No. 196900269D

TEST REPORT

(This Report is issued subject to the terms & conditions set out below)

Your Ref: - Our Ref: MM-25054/1-13/YPS Date: 28 December 2011

Subject : Testing of structural steel submitted by Greenfab Pte Ltd on 22 December 2011.

Tested For : **KOON SENG CONSTRUCTION PTE LTD**
Fu Lu Shou Complex,
149 Rochor Road,
#05-02 Singapore 188425

Attn: Mr. Albert Goh

Consultant : **LSW CONSULTING ENGINEERS PTE LTD**
Blk 261 Waterloo St #04-08
Singapore 180261

Attn: Ms. Shirley Tan / Ms. Jacelyn Lim

Subcontractor :

1) **GREENFAB PTE LTD**
Blk 8 Jalan Kukoh
#01-33
Singapore 162008

Attn: Mr. Patrick Woo

2) **WELL & ABLE INTERNATIONAL PTE LTD**
103 Defu Lane 10
#02-03 BTH Building
Singapore 539223

Attn: Mr. Raymond Wong

Project : Proposed Erection of a 4-Storey Factory Comprises of 3-Storey Production Areas and 1-Storey of Ancillary Dormitory on Lot 0653W, MK11 at 2 Sungei Kadut Loop, Singapore 729449.

ReportsOthers2011/stphy

Terms & conditions:
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SETSCO

Date and Place of Test : 23 December 2011 at Setsco Laboratory

Method of Test : GB/T 1591 : 2008 - Reduced Section Tensile Test (GB/T 228: 2002)
- 'V'-Notch Charpy Impact Test (GB/T 229: 2007)
- Chemical Composition (ASTM E 415: 2008)

Description of Sample : Eight (08) pieces of structural steel said to be Grade Q345B material were received. The specimens submitted were sampled at Shanghai Xiazhou Marine Machinery Equipment Co. Ltd.

S/No.	Sample Ref.	Sample Marking	Heat No.	Qty
1	H Beam 300 x 150 x 6.5 x 9	H1	JH11100470	01
2	H Beam 600 x 200 x 11 x 17	H2-1	JF11112481	01
3	H Beam 600 x 200 x 11 x 17	H2-2	JF11112482	01
4	H Beam 700 x 300 x 13 x 24	H3	JH11111468	01
5	H Beam 350 x 350	H4	JH11102363	01
6	H Beam 400 x 200	H5	09203012	01
7	H Beam 400 x 400	H6-1	JH11111167	01
8	H Beam 400 x 400	H6-2	JH11120081	01

Results :

1) Reduced Section Tensile Test
The tested samples met the requirements of Grade Q345B GB/T 1591: 2008 specification. (Refer to Table 1 attached)

2) 'V'-Notch Charpy Impact Test
The tested samples met the requirements of Grade Q345B GB/T 1591: 2008 specification. (Refer to Table 2 attached)

3) Chemical Composition
Refer to Table 3 attached.

YAP PA SUN
Testing Officer

CHENG KWANG MENG
Manager (Mechanical Testing)
Mechanical Technology Division

Results:

Table 1a: Reduced Section Tensile Test

Sample Reference	H Beam 300 x 150 x 6.5 x 9 Sample : H1	H Beam 600 x 200 x 11 x 17 Sample : H2-1	H Beam 600 x 200 x 11 x 17 Sample : H2-2	H Beam 400 x 200 Sample : H5	GB/T 1591 : 1994 Grade Q345B ≤ 16 mm thk Requirements
Measured Mean Width (mm)	20.01	20.06	20.06	20.04	-
Measured Mean Thickness (mm)	8.26	16.01	15.99	12.16	-
Cross-sectional Area, So (mm^2)	165.28	321.16	320.76	243.69	-
Yield Load (kN)	61.0	129.4	122.1	90.1	-
Yield Stress (N/mm^2)	369.1	402.9	380.7	369.7	Min. 345
Maximum Load (kN)	102.1	201.8	181.4	134.2	-
Tensile Strength (N/mm^2)	617.7	628.3	565.5	550.7	Min. 470 Max. 630
Elongation on 80 mm Gauge Length (%)	20	30	35	31	-
Converted Elongation on 5.65 √So Gauge Length (%)	21	27	32	30	Min. 20
Position of Fracture	Fractured within gauge mark.				-

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Results:

Table 1b: Reduced Section Tensile Test

Sample Reference	H Beam 350 x 350 Sample : H4	H Beam 700 x 300 x 13 x 24 Sample : H3	H Beam 400 x 400 Sample : H6-1	H Beam 400 x 400 Sample : H6-2	GB/T 1591 : 1994 Grade Q345B >16 to 40 mm thk Requirements
Measured Mean Width (mm)	20.10	20.04	20.06	20.10	-
Measured Mean Thickness (mm)	18.12	23.00	20.08	19.89	-
Cross-sectional Area, So (mm²)	364.21	460.92	402.80	399.79	-
Yield Load (kN)	131.1	166.9	150.7	135.5	-
Yield Stress (N/mm²)	360.0	362.1	374.1	338.9	Min. 335
Maximum Load (kN)	203.1	258.0	234.3	213.4	-
Tensile Strength (N/mm²)	557.6	559.8	581.7	533.8	Min. 470 Max. 630
Elongation on 80 mm Gauge Length (%)	34	37	31	35	-
Converted Elongation on 5.65 √So Gauge Length (%)	30	31	27	30	Min. 20
Position of Fracture	Fractured within gauge mark.				-

SETSCO

Results:

Table 2a: 'V'-Notch Charpy Impact Test

Sample Reference	Item Measured	Dimension of Test Specimen	Impact Value at +20°C (Joules)	GB/T1591-2008 Grade Q345B Requirement
H Beam 300 x 150 x 6.5 x 9 Sample : H1	Test 1	10 x 7.5 x 55 mm	30	-
	Test 2		28	
	Test 3		28	
	Average		29	Min. 25.5 (J)

Table 2b: 'V'-Notch Charpy Impact Test

Sample Reference	Item Measured	Dimension of Test Specimen	Impact Value at +20°C (Joules)	GB/T1591-2008 Grade Q345B Requirement
H Beam 600 x 200 x 11 x 17 Sample : H2-1	Test 1	10 x 10 x 55 mm	52	-
	Test 2		40	
	Test 3		42	
	Average		45	Min. 34 (J)

Table 2c: 'V'-Notch Charpy Impact Test

Sample Reference	Item Measured	Dimension of Test Specimen	Impact Value at +20°C (Joules)	GB/T1591-2008 Grade Q345B Requirement
H Beam 600 x 200 x 11 x 17 Sample : H2-2	Test 1	10 x 10 x 55 mm	76	-
	Test 2		72	
	Test 3		64	
	Average		71	Min. 34 (J)

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Results:

Table 2d: 'V'-Notch Charpy Impact Test

Sample Reference	Item Measured	Dimension of Test Specimen	Impact Value at +20°C (Joules)	GB/T1591-2008 Grade Q345B Requirement
H Beam 700 x 300 x 13 x 24 Sample : H3	Test 1	10 x 10 x 55 mm	68	-
	Test 2		68	
	Test 3		56	
	Average		64	Min. 34 (J)

Table 2e: 'V'-Notch Charpy Impact Test

Sample Reference	Item Measured	Dimension of Test Specimen	Impact Value at +20°C (Joules)	GB/T1591-2008 Grade Q345B Requirement
H Beam 350 x 350 Sample : H4	Test 1	10 x 10 x 55 mm	140	-
	Test 2		154	
	Test 3		132	
	Average		142	Min. 34 (J)

Table 2f: 'V'-Notch Charpy Impact Test

Sample Reference	Item Measured	Dimension of Test Specimen	Impact Value at +20°C (Joules)	GB/T1591-2008 Grade Q345B Requirement
H Beam 400 x 200 Sample : H5	Test 1	10 x 10 x 55 mm	66	-
	Test 2		82	
	Test 3		74	
	Average		74	Min. 34 (J)

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Results:

Table 2g: 'V'-Notch Charpy Impact Test

Sample Reference	Item Measured	Dimension of Test Specimen	Impact Value at +20°C (Joules)	GB/T1591-2008 Grade Q345B Requirement
H Beam 400 x 400 Sample : H6-1	Test 1	10 x 10 x 55 mm	90	-
	Test 2		134	
	Test 3		114	
	Average		113	Min. 34 (J)

Table 2h: 'V'-Notch Charpy Impact Test

Sample Reference	Item Measured	Dimension of Test Specimen	Impact Value at +20°C (Joules)	GB/T1591-2008 Grade Q345B Requirement
H Beam 400 x 400 Sample : H6-2	Test 1	10 x 10 x 55 mm	180	-
	Test 2		156	
	Test 3		124	
	Average		153	Min. 34 (J)

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Results:

Table 3a: Chemical Composition

Sample Reference / Element	H Beam 300 x 150 x 6.5 x 9 Sample : H1	H Beam 600 x 200 x 11 x 17 Sample : H2-1	H Beam 600 x 200 x 11 x 17 Sample : H2-2	H Beam 700 x 300 x 13 x 24 Sample : H3	GB/T1591-2008 Grade Q345B Requirements	BC1: 2008 (BS EN 10025-2: 2004) Grade S355JR Requirements
Carbon, C (%)	0.19	0.19	0.16	0.17	Max. 0.27	Max. 0.27
Silicon, Si (%)	0.49	0.38	0.37	0.31	Max. 0.60	Max. 0.60
Manganese, Mn (%)	1.56	1.48	1.46	1.41	Max. 1.70	Max. 1.70
Phosphorous, P (%)	0.028	0.033	0.024	0.035	Max. 0.050	Max. 0.045
Sulphur, S (%)	0.015	0.010	0.008	0.013	Max. 0.050	Max. 0.045
Niobium, Nb (%)	0.001	0.001	0.001	0.001	Max. 0.07	-
Vanadium, V (%)	0.005	0.007	0.006	0.004	Max. 0.15	-
Titanium, TI (%)	0.002	0.002	0.002	0.001	Max. 0.20	-
Chromium, Cr (%)	0.21	0.36 *	0.21	0.16	Max. 0.30	-
Nickel, Ni (%)	0.09	0.11	0.11	0.06	Max. 0.50	Max. 0.60
Copper, Cu (%)	0.013	0.010	0.010	0.010	Max. 0.30	-
Nitrogen, N (%)	0.003	0.003	0.004	0.006	Max. 0.012	-
Molybdenum, Mo (%)	0.001	0.001	0.001	0.001	Max. 0.10	-
Carbon Equivalent Value, CEV (%)	0.49 *	0.51 *	0.46 *	0.44	Max. 0.44	Max. 0.53

'*' – Indicated non-compliance to the requirements of GB/T1591-2008 Grade Q345B specification.

SETSCO

Results:

Table 3b: Chemical Composition

Element / Sample Reference	H Beam 350 x 350 Sample : H4	H Beam 400 x 200 Sample : H5	H Beam 400 x 400 Sample : H6-1	H Beam 400 x 400 Sample : H6-2	GB/T1591-2008 Grade Q345B Requirements	BC1: 2008 (BS EN 10025-2: 2004) Grade S355JR Requirements
Carbon, C (%)	0.17	0.20	0.20	0.15	Max. 0.27	Max. 0.27
Silicon, Si (%)	0.37	0.36	0.40	0.23	Max. 0.60	Max. 0.60
Manganese, Mn (%)	1.33	1.28	1.45	1.46	Max. 1.70	Max. 1.70
Phosphorous, P (%)	0.027	0.024	0.018	0.024	Max. 0.050	Max. 0.045
Sulphur, S (%)	0.007	0.023	0.008	0.008	Max. 0.050	Max. 0.045
Niobium, Nb (%)	0.001	0.001	0.001	0.001	Max. 0.07	-
Vanadium, V (%)	0.005	0.023	0.007	0.006	Max. 0.15	-
Titanium, Tl (%)	0.002	0.001	0.003	0.002	Max. 0.20	-
Chromium, Cr (%)	0.29	0.015	0.21	0.26	Max. 0.30	-
Nickel, Ni (%)	0.12	0.01	0.12	0.14	Max. 0.50	Max. 0.60
Copper, Cu (%)	0.011	0.026	0.012	0.013	Max. 0.30	-
Nitrogen, N (%)	0.003	0.004	0.002	0.003	Max. 0.012	-
Molybdenum, Mo (%)	0.003	0.002	0.001	0.001	Max. 0.10	-
Carbon Equivalent Value, CEV (%)	0.46 *	0.42	0.49 *	0.47 *	Max. 0.44	Max. 0.53

'*' – Indicated non-compliance to the requirements of GB/T1591-2008 Grade Q345B specification.

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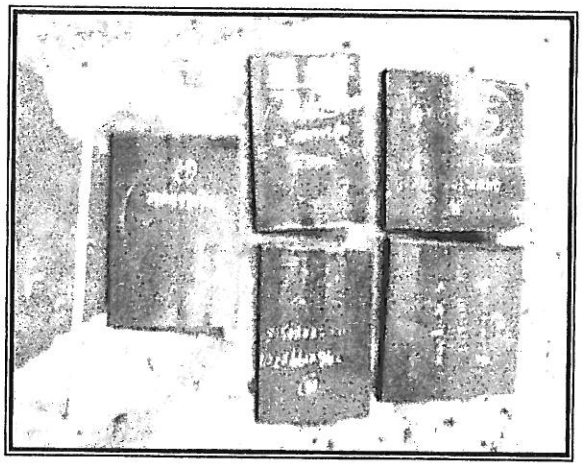
Appendix:



Photographs show samples submitted.

4.0 PART B

AUTOCLAVED LIGHTWEIGHT CONCRETE PANEL (ALCP)

4.1 DESCRIPTION

4.1.1 General Description of the Product

ALCP is a lightweight pre-cast building material that simultaneously provides structure, insulation, as well as resistance to mold and fire.

4.1.2 Usage and Application of the Product

ALCP panels can be used as external and internal construction product. This product has been used in various kinds of buildings such as external, internal and partition panels for airport, school, houses and others.

4.1.3 Element of the Product

Raw materials which includes silicon silica sand, cement, calcium lime, gypsum and small quantity of aluminum

4.1.4 Usage Limitation

Under normal condition or environment, there is **no** limitation of using ALCP as a partition.

4.1.5 Manufacturing Process

The manufacturing process applies high-temperature and high-pressure steam to create many air holes in the panel which also reinforced with anti-corrosion processed steel bar. The complete production process, from mixing raw material, anti-corrosion processing of steel bar, organizing into frame, pouring of paste, cutting, steaming, pressing, to surface processing, etc, all these process are managed, controlled accurately and consistently using specialized computer software, and stringent quality control during process. Only skim coats required for surface smoothness. The details of manufacturing process for ALCP are described in Appendix B1.

4.1.6 Technology and Skilled Required

There is technology or skilled required in mix formulation of producing lightweight concrete.

4.2. BASIS OF APPRAISAL

4.2.1 Document Received from Well & Able (M) Sdn Bhd (WASB)

The following documents were received to support the appraisal of the product.

i. Documents on the details and description of the product

ii. Test report on the product testing

4.2.2 Technical Visit

No technical visit to site has been made.

4.3 MATERIAL: SPECIFICATIONS AND TESTS

4.3.1 Specifications

i. Table of properties, size and dimension

The ALCP comes in typical size of 100 mm thick x 600 mm wide with various lengths. The details of ALCP typical panel dimensions are attached in Appendix B2.

4.3.2 Types of Testing

A series of test has been to determine the performance of the product. The types of test are listed below :

i. Test on material

Test on material is not needed.

ii. Test on product

The tests that have been performed on this product are as follows:

a. Fire Resistant Test

b. Thermal Resistance Test

c. Sound Insulation Test

d. Airborne Sound Insulation Test

e. Partition Performance Test

4.3.3 Additional Test Required

The Applicant is to notify to the Technical Expert Panel on any additional test required (if any) by fabricator or client.

4.3.4 Check on Test Report Provided by WASB

i. Test on product

The summary of the tests done and the description of the test are as shown in Table 7. The official test reports are attached in Appendix B3.

Table 7 : The summary of the description of the test and the test results.

Type of test	Result
Fire Resistance Test (Dated : 26th November 2007) *(for official test report, please refer to Appendix B3 : a (page 53 - page 67)*	
i. Structural adequacy Failure shall be deemed to have occurred when either • Collapse occurs or; • Deflection or rate of deflection occurs in excess of that specified in the relevant Section of the Standard that is applicable to the element of construction under test.	No collapse of any part of the specimen wall occurred throughout the heating period of 260 minutes. The specimen satisfied the requirements of the AS 1530.4-1997.
ii. Insulation Failure shall be deemed to have occurred when one of the following occurs : • If the mean unexposed face temperature rises by more than 140°C above its initial value • If the temperature recorded of at any position on the unexposed face rises by more than 180°C above the initial temperature.	At 240 minutes of test, the maximum mean temperature rise and maximum temperature rise above initial temperature on the unexposed face of specimen were 57.4°C and 64.9°C respectively. Therefore, the insulation of the wall partition meets the Standard for 240 minutes. The specimen satisfied the requirements of the AS 1530.4-1997.
iii. Loss of Integrity Failure shall be deemed to have occurred when either : Cracks, fissures or other opening developed and through which flames or hot gases can pass on the unexposed face or upon other occurrences as set out in the relevant Section of the	At 241 minutes, a clearance of 3mm wide by 700mm long developed beneath mortar infill along the joint line between panel B and C approximately 1000mm

Standard.	from the wall base. Therefore, the integrity of the wall partition meets the Standard for 240 minutes. The specimen satisfied the requirements of the AS 1530.4-1997.
Thermal Resistance Test (Dated : 29th August 2007) *(for official test report, please refer to Appendix B3 : b (page 68- page 71)*	Please refer to official test report for detail results
Sound Insulation Test (Dated : 26th October 2007) *(for official test report, please refer to Appendix B3 : c (page 72- page 79)*	The tested ALC floor panel system achieved a weighed normalised impact sound pressure level, $L_{n,w}$ = 92dB. Impact sound insulation rating is computed according to ISO 717-2:1996 (E).
Airbone Sound Insulation Test (Dated : 16th October 2007) *(for official test report, please refer to Appendix B3 : d (page 80 - page 87)*	The tested sample has a weighted sound reduction index, R_w (C, C_{tr}) =38 (-1.-3). Sound insulation rating is computed according to ISO 717-1:1996.
Partition Performance Test (Dated : 31st December 2007) *(for official test report, please refer to Appendix B3 : e (page 88 - page 105)*	
i. Partition stiffness The test is to establish the ability of the partition to withstand people or ladder learning against the partition wall without causing unacceptable cracking or movement.	No damaged was observed

ii. Small hard body impact This test is to simulate impact caused by sharp or pointed object such as trolleys and wheelchairs.	
i. Surface damage This test is to determine the resistance of the partition to damage from impacts by small, hardy body objects	No damage or dislodgement of partition was observed
ii. Perforation This test is to determine the resistance of the partition to perforation from impacts by small, hard objects.	No damage or dislodgement of partition was observed
iii. Large soft body impact This test is to simulate impact caused by people falling against or any large soft body object such as a ball hitting the partition wall.	
i. Resistance to surface damage	No damage observed
ii. Resistance to structural damage	No damage observed
iv. Door slam The test simulates a door being forcefully slammed by a person, wind or tensioned door closer.	No damage observed
v. Crowd Pressure The test simulates a uniform band load such as a crowd leaning against the wall.	No crack line or damage was observed

4.4 COMPLIANCE TO INTERNATIONAL STANDARDS OR EQUIVALENT

The tests on product were performed by other parties that have related product with WASB (Please refer Section 10.1). The test procedures adopted the international standards or equivalent. The standards adopted are shown in Table 8:

Table 8: Type of tests and standards adopted

Type of Test	Standard
Fire Resistance Test	**AS 1530.4-1997** Methods for fire tests on building materials, components and structure. Part 4: Fire resistance tests of element of building construction
Thermal Resistance Test	**ASTM C518-04** Standard test method for steady-state heat flux measurements and thermal transmission properties by means of the heat flow meter apparatus
Sound Insulation Test	**ISO 140-6:1998** Acoustics – Measurements of sound insulation in buildings and building elements – Part 6: laboratory measurements of impact sound insulation of floors
Airborne Sound Insulation Test	**ISO 140-3:1995** Laboratory measurements of airborne sound insulation of building elements
Partition Performance Test	**SS 492:2001 & BS 5234 Part 2:1992** Partition (including matching linings) Part 2: Specification for performance requirements for strength and robustness including methods of test

4.5 APPENDIX B

B1 : MANUFACTURING PROCESS OF ALCP

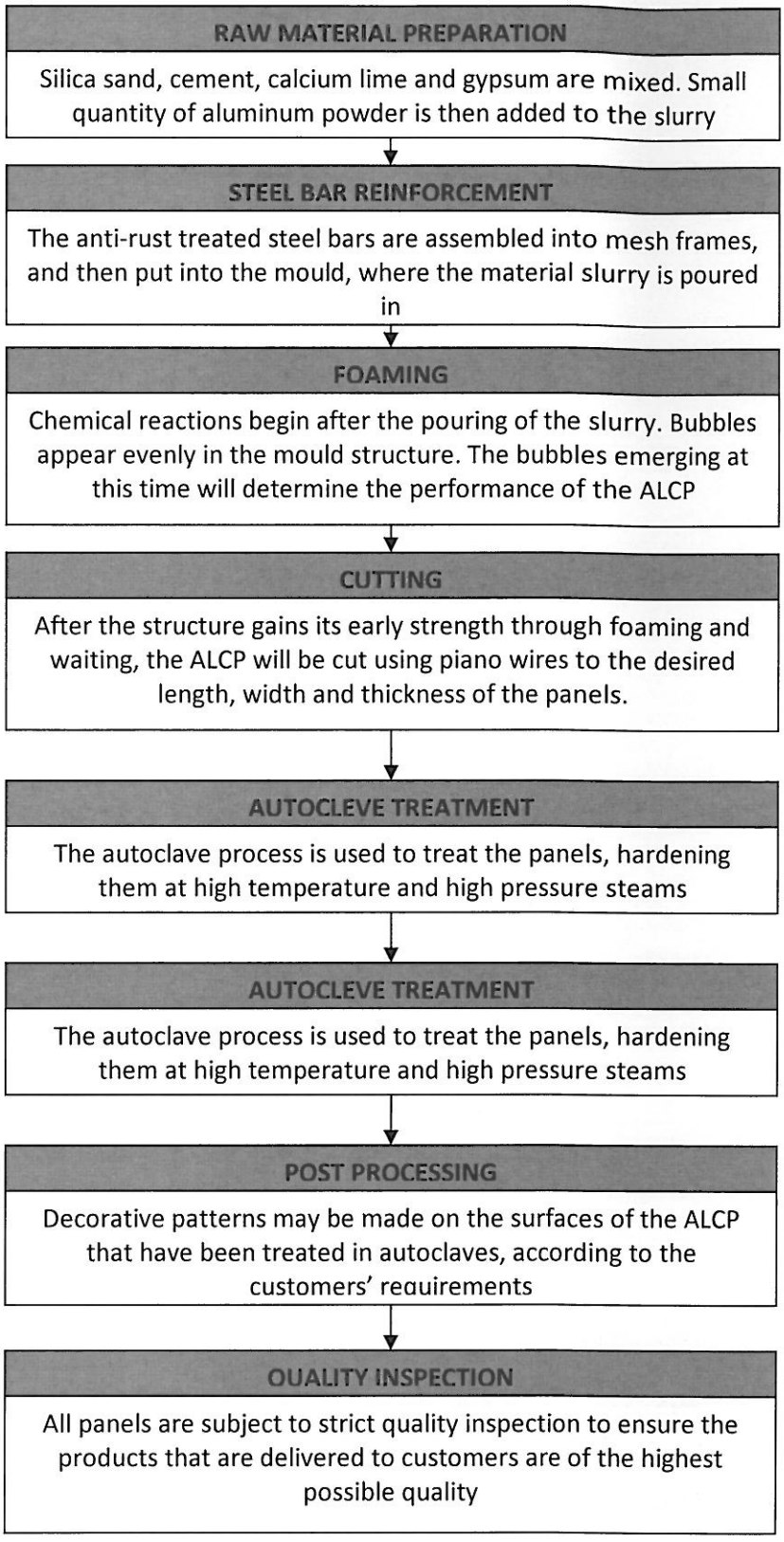
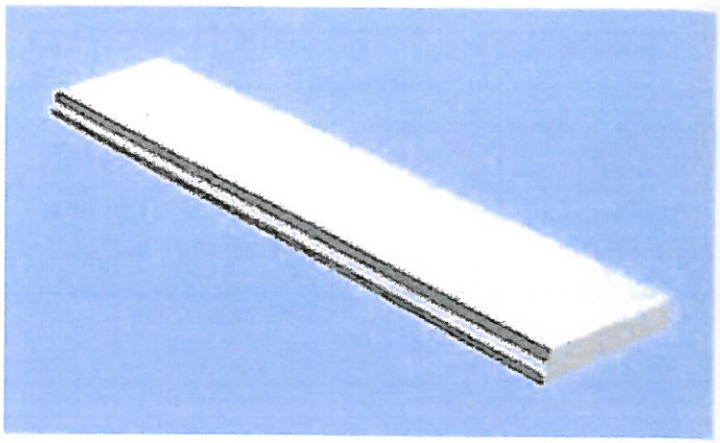
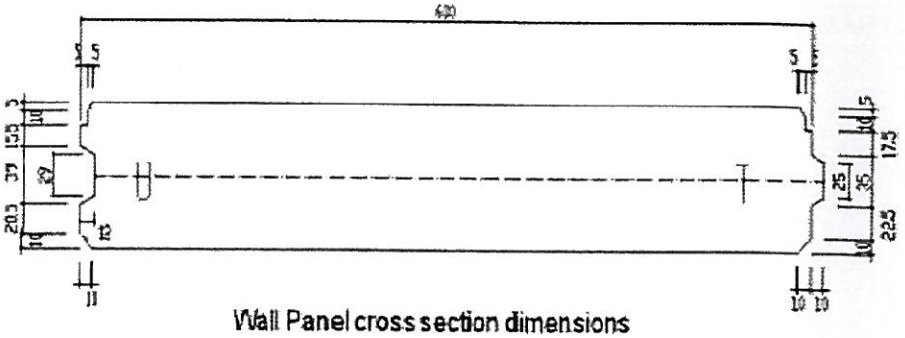


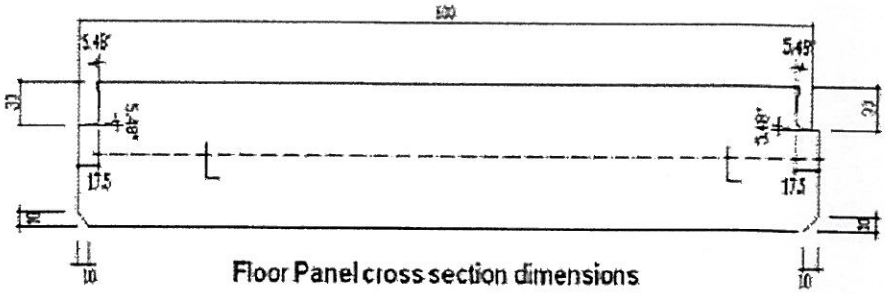
Figure 10 : Flow chart to show the manufacturing process of ALCP product

B2 : PRODUCT DIMENSION OF ALCP





Wall Panel cross section dimensions



Floor Panel cross section dimensions

Panel	Width (mm)	Length (mm)
Wall Panel 100mm thick	600	2700; 2850; 3000; & custom length
Floor Panel 100mm thick	600	2000; 2200; & custom length

B3 : TEST REPORT OF ALCP PRODUCT

a) Fire Resistance Test Report

Test Report No. S07MEC0023/IHN
dated 31 Dec 2007

Note: This report is issued subject to TÜV SÜD PSB's "Terms and Conditions Governing Technical Services". The terms and conditions governing the issue of this report are set out as attached within this report.

SUBJECT:

Fire resistance test on "Godiniland" wall partition system with asymmetrical joints constructed using Autoclave Lightweight Concrete (ALC) submitted by Godiniland.

TESTED FOR:

GISS Pty Ltd
Ground Floor, 2 Mill Street
PO Box 343
Perth WA 6000
Australia

Attn: Mr. Dave Teh

DATE SUBMITTED:

26 Nov 2007

DATE OF TEST:

07 Dec 2007

PURPOSE OF TEST:

1 To determine the fire resistance of the specimen when tested in accordance with AS 1530.4-1997 "Methods for fire tests on building materials, components and structures. Part 4: Fire resistance tests of elements of building construction". The test was performed in accordance with Section 2 (General Requirements) and Section 3 (Walls and Partitions) of the standard mentioned.

Laboratory:
TÜV SÜD PSB Pte. Ltd.
Testing Group
No.1 Science Park Drive
Singapore 118221

Phone : +65-6885 1333
Fax : +65-6776 8670
E-mail: testing@tuv-sud-psb.sg
www.tuv-sud-psb.sg
Co. Reg : 199002667R

Regional Head Office:
TÜV SÜD Asia Pacific Pte. Ltd.
3 Science Park Drive
#04-01/05 The Franklin
Singapore 118223

TEST PROCEDURE:

2 Before the commencement of test, the ambient temperature in the general vicinity of the test specimen construction was ensured to be not exceeding 35°C. The datum values for each individual temperature and deflection measurements were recorded not more than 15 minutes before the commencement of test.

3 During the test, with commencement of heating of the specimen, the furnace temperature and pressure were controlled to comply with the requirements specified in AS 1530.4-1997 Section 2 Clause 2.9.1, 2.9.2 and 2.9.3. The pressure was controlled such that a linear pressure gradient of 8.5±2 Pa per 1000mm height exist above a neutral pressure axis at a height of approximately 500mm above the notional floor level. However, the maximum pressure at the top of a vertical test construction shall not exceed 20Pa.

4 Throughout the course of the test, observation was made of the behaviour of the specimen for compliance with the relevant performance criteria stated in Clause 2.11 (Criteria of Failure) of AS 1530.4-1997 with emphasis on structural adequacy, integrity and insulation.

5 Mean temperature on the unexposed face of insulated specimen were measured by five number of surface mounted thermocouples, with one positioned approximately at the centre area and one approximately at centre of each quadrant.

6 Maximum temperatures on the unexposed face of insulated specimen were measured by two additional surface mounted thermocouples positioned at locations deemed to be hotter than those specified to be the average on the surface.

7 Observations, on the behaviour of the test specimen throughout the heating period, were made and recorded. As appropriate, cotton pads, gap gauges and roving thermocouple were used to establish the occurrence of failure.

8 The test was terminated when one or more failures as stated in the performance criteria occurred, or otherwise at a time agreed between the sponsor of test and the test laboratory.

PERFORMANCE CRITERIA:

9 The specimen is assessed against the following test criteria:

9.1 Structural adequacy

Failure shall be deemed to have occurred when either:

- Collapse occurs or
- Deflection or rate of deflection occurs is in excess of that specified in the relevant Section of the Standard that is applicable to the element of construction under test.

9.2 Loss of Integrity

Failure shall be deemed to have occurred when either:

- Cracks, fissures or other openings developed and through which flames or hot gases can pass on the unexposed face or upon other occurrences as set out in the relevant Section of the Standard.

9.3 Insulation

Failure shall be deemed to have occurred when one of the following occurs:-

- If the mean unexposed face temperature rises by more than 140°C above its initial value.
- If the temperature recorded of at any position on the unexposed face rises by more than 180°C above the initial temperature.

DESCRIPTION OF TEST SPECIMEN:

10 The test specimen consisted of a non load bearing 3000mm (wide) x 3000mm (high) "Godiniland" wall partition system constructed with Autoclaved Lightweight Concrete (ALC) partition wall of 100mm nominal thickness. The wall with asymmetrical joints was vertically constructed within a test frame with ordinary bricks of size 215mm x 90mm x 75mm placed along the base as lateral support and along two vertical sides of the wall. A thermal expansion gap of approximately 20mm wide filled with ceramic wool was provided along one vertical edge of the constructed wall. The test frame was mounted onto the test furnace (PSB Asset No: 20009077) and the test was conducted at TÜV SÜD PSB Pte Ltd. fire test laboratory located at No. 10 Tuas Ave 10, Singapore 639134.

11 Five panels of Autoclaved Lightweight Concrete (ALC), with the word "Siporex" stamped on the base, were vertically erected and interlocked with a tongue and groove jointing along the longitudinal edge. Each panel was reinforced with diameter 6mm steel rods embedded within the core. The nominal dimensions of each "Siporex" Autoclaved Lightweight Concrete (ALC) panel was 600mm (wide) x 3000mm (high) x 100mm (thick) and the bulk density was found to be 662kg/m^3 . Interfacing vertical joints between each panel and along the wall perimeter were grouted with ordinary cement mixture on the exposed and unexposed faces.

12 An inspection on the specimen was conducted during the construction stages by a TÜV SÜD PSB staff to verify on its material used, dimensions and designs. Details of the partition wall are as shown in Figure 2 to 4.

13 Installation of the test specimen onto the test furnace was arranged and carried out by TÜV SÜD PSB Pte Ltd.

TEST RESULTS:

14 Table 1 shows the temperature rise for the furnace and the standard curve. In addition, the table shows the percentage difference between the area under the standard curve and the area under the furnace curve compared with the percentage tolerance allowable within the standards.

15 Table 2 and 3 show the mean and maximum unexposed face temperature above the initial temperature.

16 Table 4 shows the deflection measurement of the drywall partition towards the furnace along its mid-height.

17 Figure 1 shows the actual time-temperature curve of furnace in relation to the specified time-temperature curve.

18 Photographs of the test are shown in Plates 1 to 4.

19 Observations were made during the test on the unexposed face of the test specimen and these are given in Appendix 1 of this report.

20 The results of this fire test may be used to directly assess fire hazard, but it should be recognised that a single test method will not provide a full assessment of fire hazard under all fire conditions.

CONCLUSION:

21 The specimen satisfied the requirements of the AS 1530.4-1997 for the periods stated below:

Structural adequacy	:	260 minutes
Integrity	:	240 minutes
Insulation	:	240 minutes

REMARKS:

22 Structural adequacy

No collapse of any part of the specimen wall occurred throughout the heating period of 260 minutes.

23 Integrity

At 241 minutes, a clearance of 3mm wide by 700mm long developed beneath mortar infill along the joint line between panels B and C approximately 1000mm from the wall base. Therefore, the integrity of the wall partition meets the standard for 240 minutes.

24 Insulation

At 240 minutes of test, the maximum mean temperature rise and maximum temperature rise above initial temperature on the unexposed face of specimen were 57.4°C and 64.9°C respectively. Therefore, the insulation of the wall partition meets the standard for 240 minutes.

Ismail Bin Hassan
Associate Engineer

Chan Lung Toa
Product Manager
(Fire Safety & Security Products)
Mechanical

Table 1: Comparison of area under the curve

Time (min)	Temperature rise (°C)		Area under curve (°C min)		Percentage difference (%)	Standard tolerance ±%
	Standard	Furnace	Standard	Furnace		
5.0	556.4	563.7	2038.1	2043.1	0.2	15.0
10.0	658.4	655.4	5102.7	5094.2	-0.2	
15.0	718.6	720.6	8554.8	8550.3	-0.1	10.0
30.0	821.8	822.6	20195.3	20194.1	0.0	
60.0	925.3	924.9	46579.6	46576.7	0.0	5.0
120.0	1029.0	1029.2	105566.9	105558.2	0.0	
180.0	1089.7	1090.1	169252.9	169247.1	0.0	
240.0	1132.8	1134.1	235991.4	235986.6	0.0	
260.0	1144.8	1143.4	258769.2	258764.4	0.0	

Table 2: Unexposed face temperature of the Wall Partition

Time (min)	Thermocouple no.					Mean Temp (°C)	Above initial mean temp (°C)	
	100	101	102	104	105		Mean temp	Max. temp
0.0	26.8	27.8	27.5	27.5	27.0	27.3	-	-
15.0	27.3	27.8	27.8	28.0	27.5	27.7	0.4	0.6
30.0	33.6	34.7	34.5	33.4	33.2	33.9	6.6	7.0
60.0	72.5	73.9	76.0	73.4	75.4	74.2	46.9	48.5
120.0	78.9	80.4	82.7	80.7	81.5	80.8	53.5	55.3
180.0	81.8	83.0	85.2	84.9	83.9	83.8	56.4	57.7
240.0	82.6	83.5	86.2	86.0	85.1	84.7	57.4	58.7

Note: The mean temperatures were derived from thermocouple points 100 to 102 and 104 to 105.

Table 3: Additional unexposed face temperature of the Wall Partition

Time (min)	Thermocouple no.		Mean Temp (°C)	Max. temp above initial temp (°C)
	106	108		
0.0	27.4	27.2	27.3	-
15.0	28.0	27.5	27.8	0.6
30.0	34.7	33.9	34.3	7.3
60.0	74.7	73.3	74.0	47.3
120.0	83.4	81.9	82.6	56.0
180.0	87.0	84.4	85.7	59.6
240.0	92.3	84.8	88.6	64.9

Table 4 : Deflection of the Wall Partition towards the furnace

Time (min.)	Measurement of deflection (mm)				
	A	B	C	D	E
10.0	4	6	3	1	3
20.0	4	8	5	3	3
30.0	9	10	11	9	3
45.0	11	14	14	11	3
60.0	9	14	12	10	3
90.0	6	9	8	6	3
120.0	4	5	7	2	3
150.0	4	2	0	0	1
180.0	3	2	0	0	3
210.0	4	3	2	0	0
240.0	12	26	33	14	3

Note: The measuring points at mid-height of the wall are indicated in Figure 2.

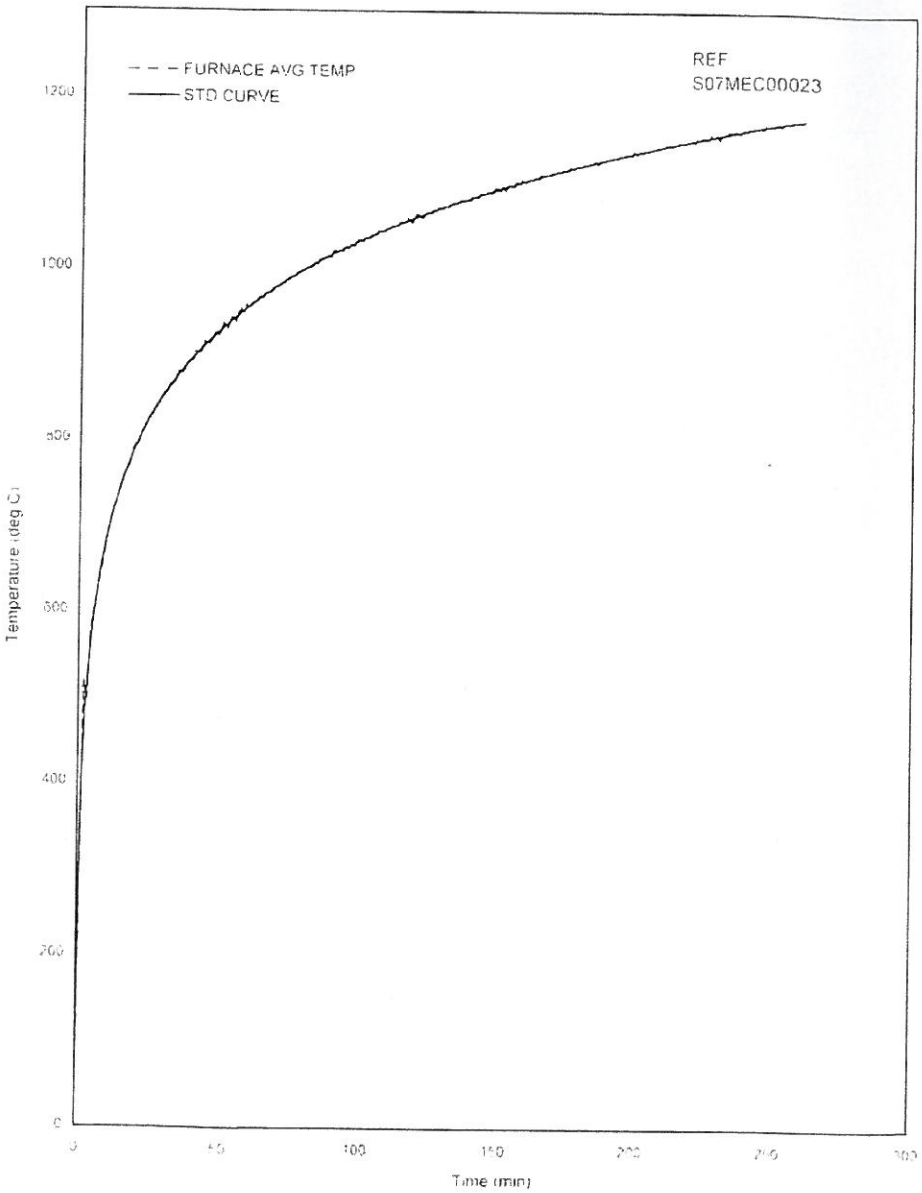


FIGURE 1 FURNACE AVERAGE TEMPERATURE

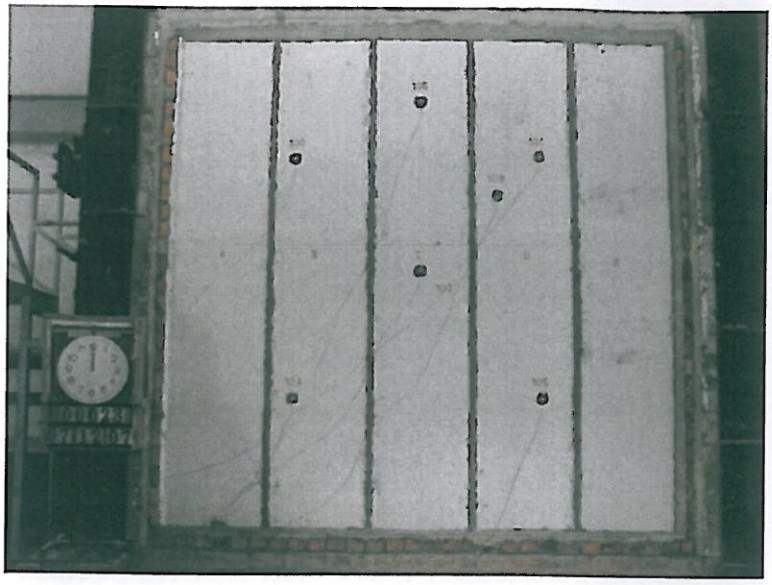


Plate 1: The unexposed face of specimen before test.

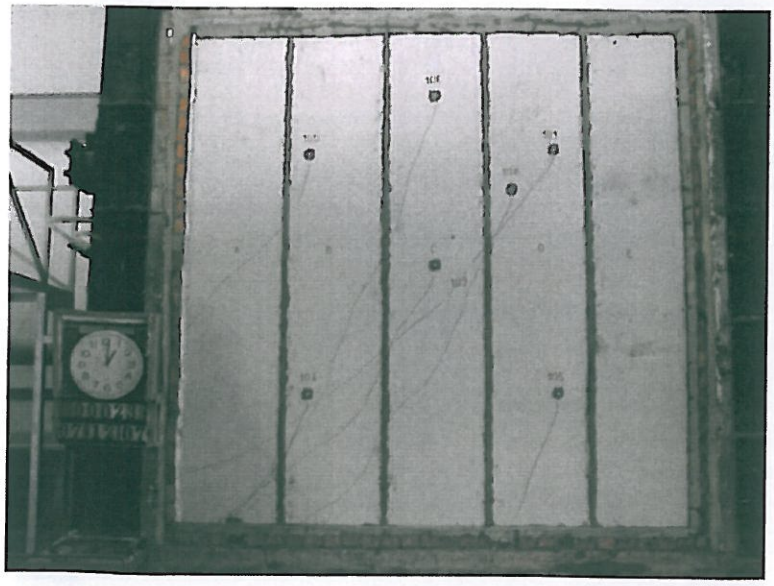


Plate 2: At about 60 minutes of test.

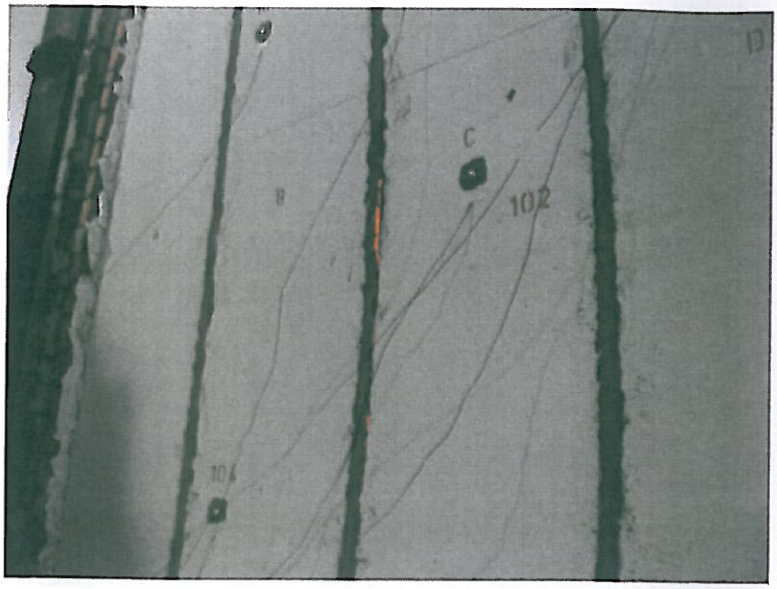


Plate 3: At about 241 minutes of test.

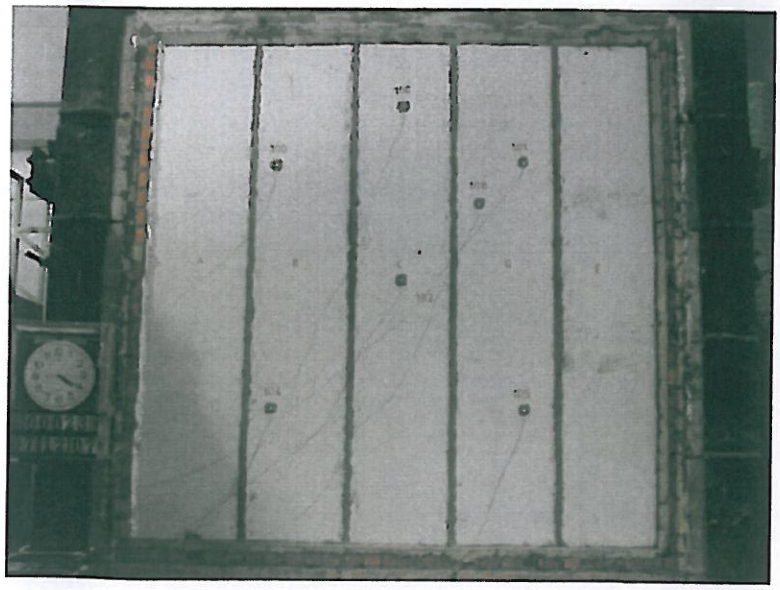


Plate 4: At about 260 minutes of test.

APPENDIX 1

Time (min:sec)	Observation on the unexposed face
00:00	Test commenced.
18:00	Small volume of smoke released from panels longitudinal joints.
30:00	Integrity of wall remained intact. Slight inward deflection was recorded across wall mid-height.
40:00	Slight clearance developed beneath mortar infill between vertical joint of panel D and E at wall mid-height.
60:00	Integrity was observed to remain intact and increased inward deflection across wall mid-height was recorded.
120:00	Integrity remained intact.
180:00	No significance occurrence was observed.
240:00	Increased inward deflection along the wall mid-height was recorded and the integrity of wall was intact.
241:00	A radiating hot opening of approximately 3mm wide by 700mm long developed beneath mortar infill along the joint line between panel B and C approximately 1000mm from wall base. **Integrity of the wall was deemed to have failed.**
250:00	A digital roving thermocouple was placed about 50mm from the radiating hot opening mentioned at 241 minutes on the unexposed face and a temperature of 225°C was recorded.
254:00	Hairline cracks begun to emerge on of all panels surface.
260:00	Test was terminated.

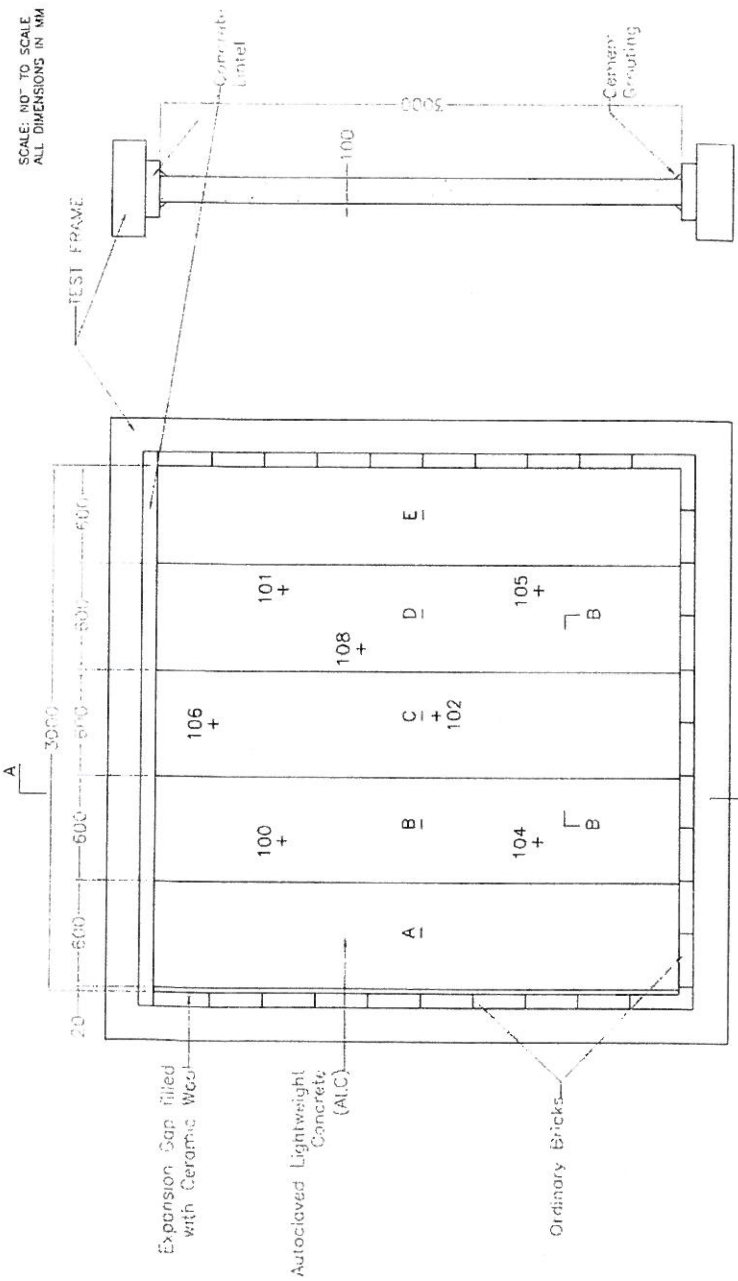


FIGURE 3 : SECTION A–A

'+' Indicates thermocouple points.

'–' Indicates deflection measurement points at mid-height.

FIGURE 2 : GENERAL ARRANGEMENT OF WALL ON THE UNEXPOSED SIDE

SCALE: NOT TO SCALE
ALL DIMENSIONS IN MM

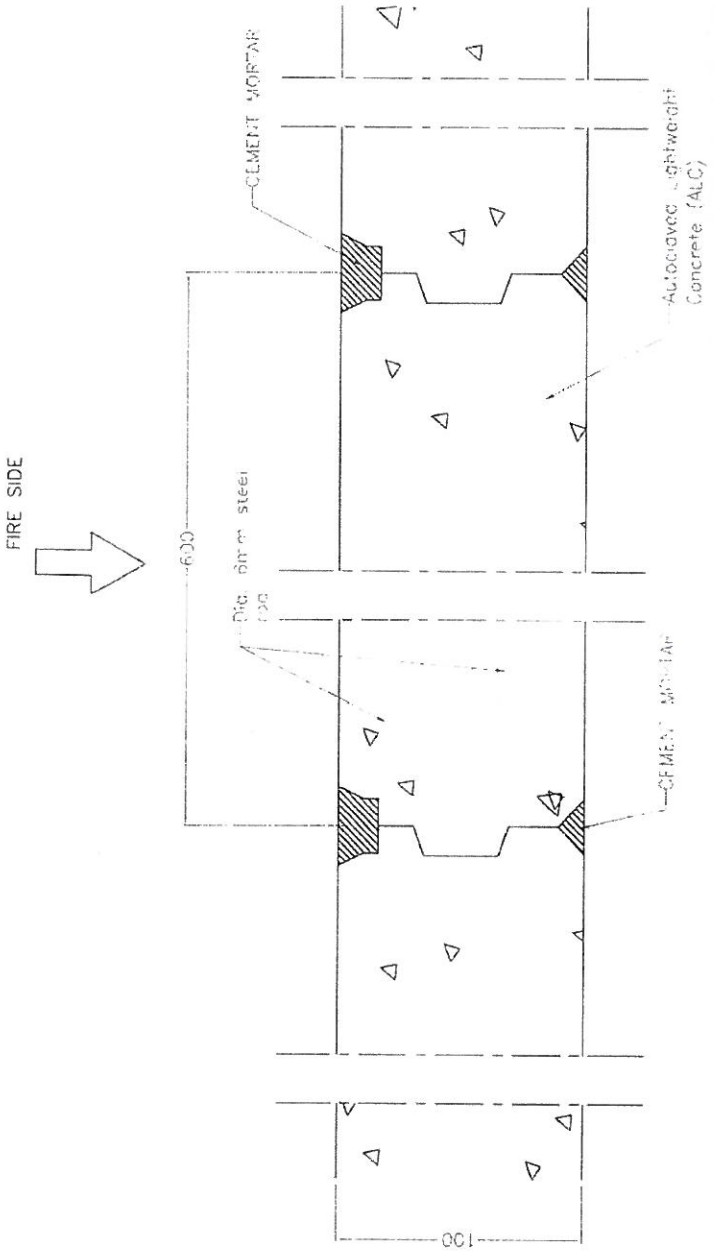


FIGURE 4 : SECTION B–B

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10. Unless otherwise stated, the tests are carried out in TÜV SÜD PSB Pte Ltd, No.1 Science Park Drive Singapore 118221.

May 2007

b) Thermal Resistance Test Report

BRANZ

EC1392/1

Thermal Resistance of a lightweight concrete panel

Author: Ian Cox-Smith
Building Physicist
IANZ Approved Signatory

Reviewer: Sheng-Huei Huang
Technician
IANZ Approved Signatory

All tests reported herein have been undertaken at the BRANZ Ltd laboratories located in Judgeford, Porirua, New Zealand, unless stated otherwise.

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International Accreditation New Zealand (IANZ) has a Mutual Recognition Agreement (MRA) with the National Association of Testing Authorities, Australia (NATA). Users of test reports are recommended to accept test reports in the name of either accrediting body.

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   vii. BRANZ shall have no liability for any indirect or consequential loss (including loss of profits).
   viii. In the event of any claim the Client must give written notice to BRANZ within 30 days of discovery of the facts alleged to justify such claim and, in any case, BRANZ shall be discharged from all liability for all claims for loss, damage or expense unless legal proceedings are commenced in respect of the claim within one year from:
      - The date of performance by BRANZ of the service which gives rise to the claim; or
      - The date when the service should have been completed in the event of any alleged non-performance.

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   ii. any misstatement or misrepresentation of the Outputs, including Public Outputs;
   iii. any defects in the Products the subject of the Services; or
   iv. any changes, modifications or alterations to the Products the subject of the Services.

Thermal Resistance of a lightweight concrete panel

1. CLIENT

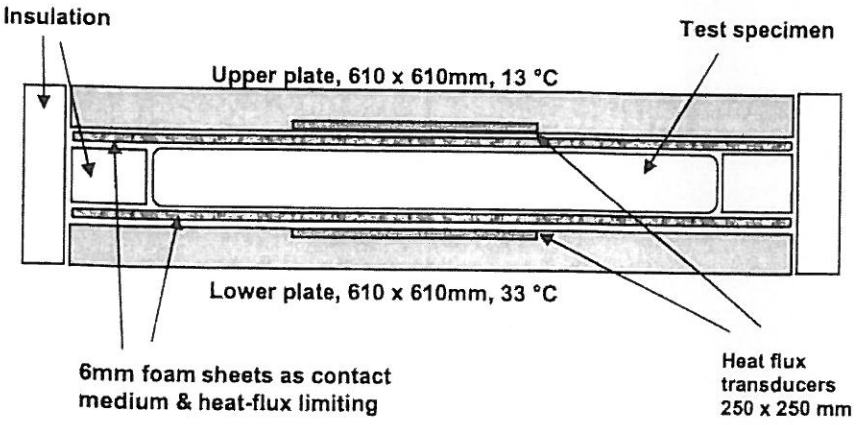
GISS PTY LTD
Ground Floor, 2 Mill Street
Perth WA 6000
AUSTRALIA

2. DESCRIPTION OF TEST EQUIPMENT

The test equipment used was a LaserComp Fox 600 heat flow meter. The specimen for testing is placed horizontally in the apparatus, with upwards heat flows. The hot and cold plates each have a 250 mm x 250 mm heat flux transducer embedded in their surface. The edges of the specimen are insulated from the room ambient temperature. The uncertainty in individual thermal conductivity and thermal resistance measurements is estimated to be 5%.

The sample supplied by the client consisted of a section of lightweight concrete panel with dimensions 480 mm x 450 mm by approximately 100 mm thickness. The sample weight was 15.4 kg, giving an apparent sample density of approximately 720 kg/m^3.

Figure 1. Apparatus



ICS

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3. PROCEDURE

The test setup (figure 1) consisted of the test specimen sandwiched between sheets of 6 mm compressible foam plastic. The foam sheets act as contact media between the apparatus plates and the sample, minimising contact thermal resistance. Since the foam sheets add additional insulation they also serve the purpose of limiting the heat-flux to values that can be measured accurately by the apparatus.

The sample was made up to the test specimen size of 610 mm x 610 mm by the inclusion of pieces of insulation the same thickness and tested to the requirements of ASTM C518-04.

The thermal resistance of the sample is determined by subtracting the thermal resistances of the foam sheets (previously measured) from the total measured thermal resistance of the test specimen (sample plus two foam sheets).

Although a thermal conductivity has been calculated for the sample, it is the thermal resistance that is measured, and it is an apparent thermal conductivity that has been calculated.

The HFM calibration was checked immediately after completing the test using the two foam sheets, BRANZ secondary reference sample '2xfoam'.

4. RESULTS

Sample reference	D4003
HFM plate spacing (mm)	111.6
Thickness of foam sheets (mm)	13.0
Mean temperature (°C)	23.0
Temperature difference (K)	20.0
Heat flux (W/m^2)	28.8
Difference between heat-flux transducers (%)	5.0
Total thermal resistance ($m^2.K/W \pm 4\%$)	0.693
Thermal resistance of foam sheets ($m^2.K/W \pm 3\%$)	0.376
Therefore:	
Sample thickness (mm)	98.6
Apparent sample density (kg/m^3)	720
Thermal resistance of sample ($m^2.K/W \pm 5\%$)	0.317
Apparent thermal conductivity of sample ($W/mK \pm 5\%$)	0.311

5. REFERENCES

ASTM C518-04. *Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.*

American Society for Testing and Materials, Philadelphia, PA, 2002.

ICS

SHH

c) Sound Insulation Test Report

Test Report No. 54S076035/B/EMK
dated 30 Oct 2007

Note: This report is issued subject to TÜV SÜD PSB Corporation's "Terms and Conditions Governing Technical Services". The terms and conditions governing the issue of this report are set out as attached within this report.

SUBJECT:

Laboratory measurement of impact sound insulation on "GISS" autoclaved lightweight concrete (ALC) floor panel was submitted by Godiniland on 19 Sep 2007.

TESTED FOR:

Godiniland
Ground Floor, 2 Mill Street,
Perth West Australia 6000

Attn: Mr David Teh

DATE OF TEST:

26 Oct 2007

DESCRIPTION OF SAMPLE:

A "GISS" autoclaved lightweight concrete (ALC) floor panel system was installed on the horizontal opening of the reverberation room for impact sound insulation test by Tarlic Engineering Construction.

Dimension	Quantity
a) 2.00m (length) x 0.60m (width) x 100mm (thick)	5 pieces
b) 2.00m (length) x 0.39m (width) x 100mm (thick)	1 piece
c) 1.39m (length) x 0.60m (width) x 100mm (thick)	5 pieces
d) 1.39m (length) x 0.39m (width) x 100mm (thick)	1 piece

The density of the ALC floor panel is said to be 750kg/m^3.

The exposed area of the ALC floor panel system for testing was 3400mm (length) x 3400mm (width). Sealant was used to seal all the boundaries of the floor panel system.

PSB TEST
Your Peace of Mind

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Testing Group
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Singapore 118221

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Co. Reg : 199002667R

Regional Head Office:
TÜV SÜD Asia Pacific Pte. Ltd.
3 Science Park Drive
#04-01/05 The Franklin
Singapore 118223

METHOD OF TEST:

The test was conducted to ISO 140-6 : 1998 "Acoustics – Measurement of sound insulation in buildings and of building elements – Part 6 : Laboratory measurements of impact sound insulation of floors"

Area of test specimen: 11.56m^2
Air temperature in reverberation room: 26°C
Relative air humidity in reverberation room: 70%
Reverberation room volume: 86m^3
Location of the test: Acoustics Lab of TÜV SÜD PSB Pte Ltd

TEST EQUIPMENT:

The following instruments were used for the test.

1) A dual-channel real-time frequency analyser (B&K Type 2133)
2) A tapping machine (B&K Type 3207)
3) A ½" condenser microphone with preamplifers (B&K Type 4190)
4) A sound pressure level calibrator (Norsonic Type 1251)
5) A set of rotating microphone booms (B&K Type 3923)

TEST PROCEDURES:

1) Instrumentation was set up according to ISO 140-6.

2) Measurement system was calibrated using a sound level calibrator Norsonic Type 1251.

3) Background noise level for reverberation room was measured.

4) Tapping machine was switched on and placed on the top surface of the roof system at 45° to the direction of the beams and maintained at constant noise level. The sound pressure level in the reverberation room was ensured to be 15dB higher than the background noise level.

5) Recording time for both rotating microphone booms was set to 64s which equals to the time taken by the booms to complete two revolutions.

6) Impact sound pressure level in the reverberation room was measured with a dual – channel acoustic analyser (B&K 2133), and the measurement was repeated twice.

7) Step 4 was repeated thrice at 3 different tapping positions.

8) Reverberation time (RT) of the reverberation room was measured from two different loudspeaker positions.

9) The mean values of the four readings for impact sound pressure level and four readings for RT values were calculated.

10) Values of normalised impact sound pressure level and sound absorption area were determined for each 1/3 octave frequency band from 100Hz to 5kHz based on the mean values of step 9.

11) Weighted normalised impact sound pressure level was calculated based on the values of step 10.

RESULTS:

Values of normalised impact sound pressure level (L_n) of the roof system were tabulated in Table 1. Impact Sound Insulation Rating is computed according to ISO 717 - 2 : 1996(E) "Acoustics - Rating of sound insulation in buildings and of building elements – Part 1: Airborne sound insulation".

Table 1 : Measured values of R and values of the shifted reference curve for $L_{n,w}$ - 92dB

1/3 Octave Band Frequency (Hz)	Measured Normalised Impact Sound Pressure Level, L_n (dB)	Shifted Reference Curve, $L_{n,w}$ = 92(dB)	Deficiency
100	67	94	0
125	70	94	0
160	71	94	0
200	73	94	0
250	76	94	0
315	78	94	0
400	82	93	0
500	85	**92**	0
630	87	91	0
800	88	90	0
1000	88	89	0
1250	88	86	2
1600	87	83	4
2000	87	80	7
2500	85	77	8
3150	82	74	8
4000	77	71	-
5000	70	68	-
		Total deficiency (100Hz – 3150Hz) :	29

Note: The values in Table 1 were plotted as shown in Figure 1.

Remarks:

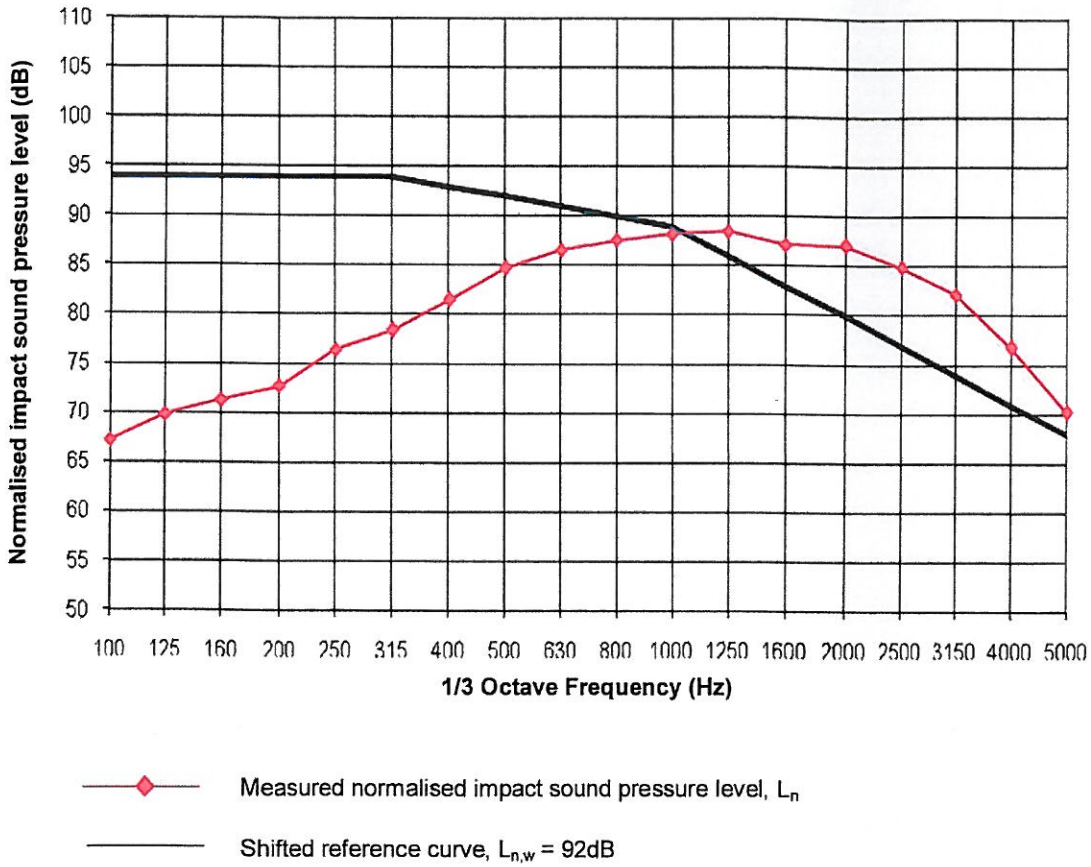
The tested ALC floor panel system achieved a weighted normalised impact sound pressure level, $L_{n,w}$ = 92

Ee Min Kuen
Testing Officer

Dr Sun Qiqing
Assistant Vice President
Acoustics & Packaging
Testing Group

RESULTS: (cont'd)

Figure 1 : Impact sound insulation performance of on "GISS" autoclaved lightweight concrete (ALC) floor panel



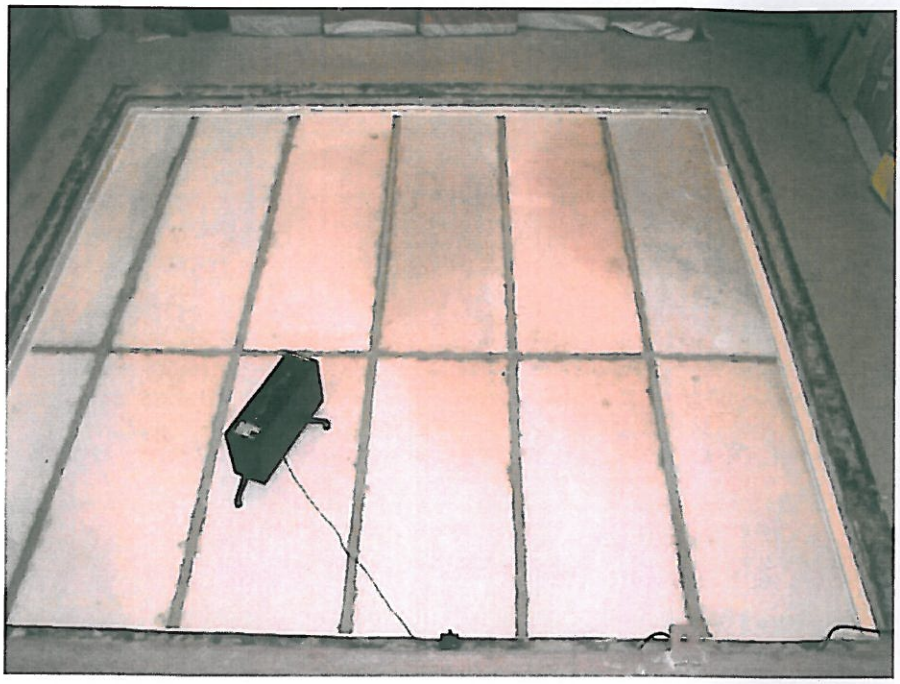


Figure 2 : Test setup of impact machine on floor panel system

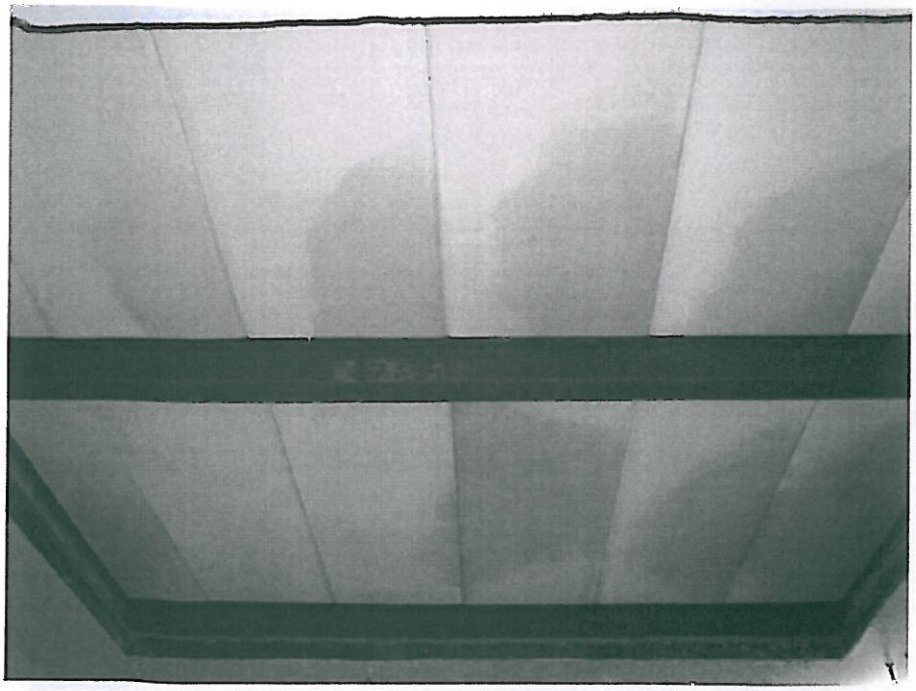
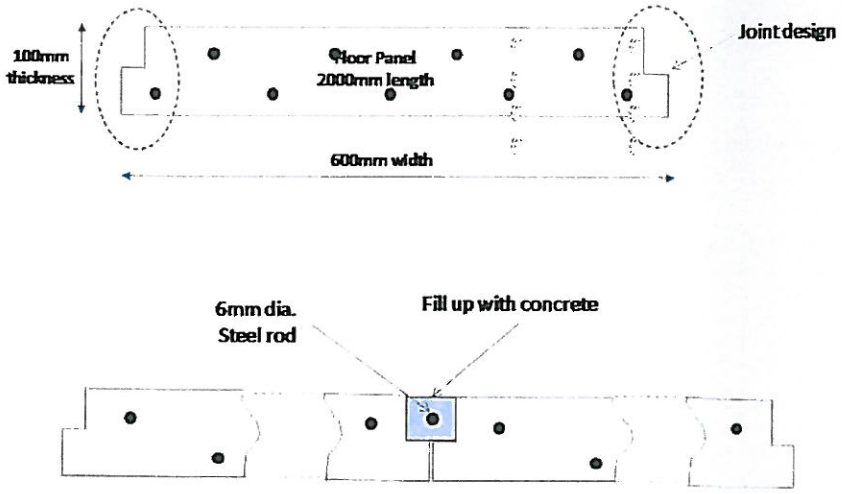


Figure 3 : Test setup of floor panel system installed on top of the reverberation room



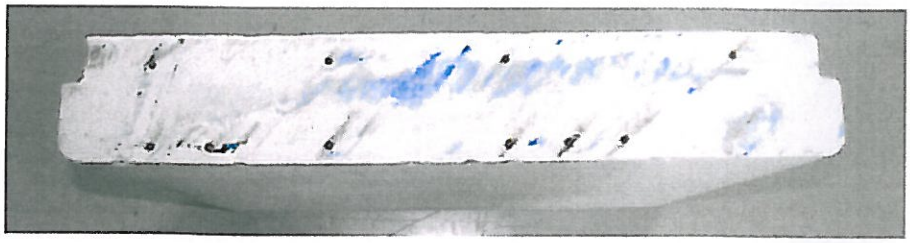


Figure 4 : Joint Detail and Cross Section of ALC floor panel

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May 2007

d) Airborne Sound Insulation Test Report

Test Report No. 54S076035/A/LCM
dated 22 Oct 2007

Note: This report is issued subject to TÜV SÜD PSB's "Terms and Conditions Governing Technical Services". The terms and conditions governing the issue of this report are set out as attached within this report.

SUBJECT:

Laboratory measurement of airborne sound insulation of "GISS" autoclaved lightweight concrete (ALC) wall panel submitted by Godiniland on 19 Sep 2007.

TESTED FOR:

Godiniland
Ground Floor, 2 Mill Street,
Perth West Australia 6000

Attn: Mr David Teh

DATE OF TEST:

16 Oct 2007

DESCRIPTION OF SAMPLE:

A "GISS" autoclaved lightweight concrete (ALC) wall panel system of dimension of 3.19m (width) x 3.16m (height) x 100mm (thick) was installed onto the sample carrier by Tarlic Engineering Construction.

Dimension	Quantity
a) 3.19m (length) x 0.6m (width) x 100mm (thick)	5 pieces
b) 3.19m (length) x 0.19m (width) x 100mm (thick)	1 piece

The density of the ALC wall panel is said to be 750kg/m^3.

ALC grout and sealant was used to seal the joint of the external side of the wall. Normal concrete was used to seal the joint of the internal side of the wall.

METHOD OF TEST:

The test was conducted in accordance with ISO 140 – 3 : 1995 "Laboratory measurements of airborne sound insulation of building elements".

Area of test specimen : 3.185m x 3.160m = 10.07m^2
Air temperature in both source room and receiving room : 26°C
Relative air humidity in both source room and receiving room : 59%
Source room volume : 73m^3
Receiving room volume : 86m^3
Location of the test : Acoustics Lab of TÜV SÜD PSB Pte Ltd

TEST EQUIPMENT:

The following instruments were used for the test.

1) A dual-channel real-time frequency analyser (B&K Type 2133)
2) An Omni-loudspeaker (B&K Type 4296)
3) Two sets of ½" condenser microphones (B&K Type 4190)
4) Two sets of microphone preamplifers (B&K Type 2669)
5) A sound pressure level calibrator (Norsonic Type 1251)
6) A sound source amplifier (Crown model CE 1000)
7) Two sets of rotating microphone booms (B&K Type 3923)

TEST PROCEDURES:

1) Instrumentation was set up according to ISO 140 - 3.

2) Measurement system was calibrated using a sound level calibrator Norsonic Type 1251.

3) Background noise level for both source room and receiving room were measured.

4) Sound source system was switched on and maintained at constant level. The sound pressure level in the receiving room was ensured to be 15dB higher than the background noise level.

5) Recording time for both rotating microphone booms was set to 64s which equals to the time taken by the booms to complete two revolutions.

6) Sound pressure level difference between the source room and the receiving room was measured with a dual – channel acoustic analyser (B&K 2133), and the measurement was repeated 3 times.

7) Step 6 was repeated after the loudspeaker was moved to new position.

8) Reverberation time (RT) of the receiving room was measured from two different loudspeaker positions. Each loudspeaker position was measured 2 times.

9) The mean values of the six readings for sound pressure level difference and four readings for RT values were calculated.

10) Values of sound reduction index were determined for each 1/3 octave frequency band from 100Hz to 5kHz based on the mean values of step 9.

11) Weighted sound reduction index (R_w) (single number for rating sound insulation of the sample) and its adaptation terms (C, C_{tr}) according to ISO 717-1 was determined at the frequency of 500Hz of the shifted reference curve (see figure 1).

RESULTS:

Values of sound reduction index (R) of the tested sample were tabulated in Table 1. Sound Insulation Rating is computed according to ISO 717 - 1 : 1996 "Acoustics - Rating of sound insulation in buildings and of building elements – Part 1: Airborne sound insulation".

Table 1 : Measured values of the test sample and values of the shifted reference curve for $R_w = 38$

1/3 Octave Band Frequency (Hz)	Measured Sound Reduction Index, R (dB)	Shifted Reference Curve $R_w = 38$ (dB)	Deficiency
100	32.1	19.0	0.0
125	34.7	22.0	0.0
160	33.4	25.0	0.0
200	30.8	28.0	0.0
250	29.6	31.0	1.4
315	29.7	34.0	4.3
400	30.0	37.0	7.0
500	30.8	**38.0**	7.2
630	33.6	39.0	5.4
800	37.8	40.0	2.2
1000	40.9	41.0	0.1
1250	43.1	42.0	0.0
1600	45.9	42.0	0.0
2000	47.8	42.0	0.0
2500	49.9	42.0	0.0
3150	51.9	42.0	0.0
4000	53.9	42.0	0.0
5000	56.1	42.0	0.0
Total deficiency (125Hz – 4000Hz) :			**28**

The values in Table 1 were plotted as shown in Figure 1.

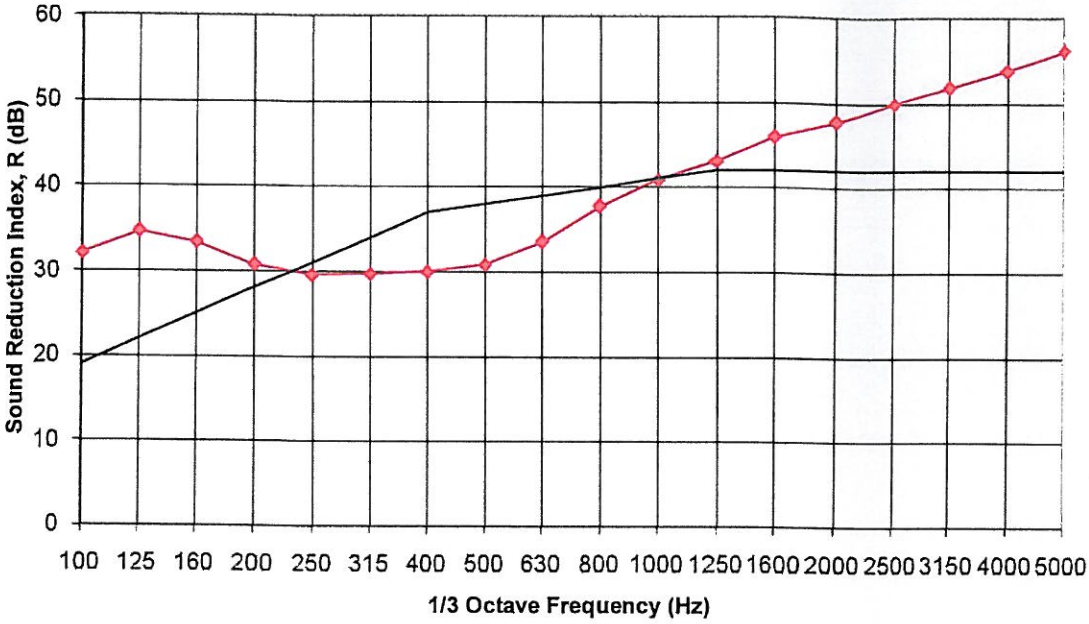
Remark: The tested sample has a weighted sound reduction index, $R_w (C, C_{tr}) = 38 (-1, -3)$.

Lem Chee Meng
Testing Officer

Dr Sun Qiqing
Assistant Vice President
Acoustics & Packaging
Testing Group

RESULTS: (cont'd)

Figure 1 : Sound insulation performance of "GISS" autoclaved lightweight concrete wall panel



Measured sound reduction index, R

Shifted reference curve, R_w = 38

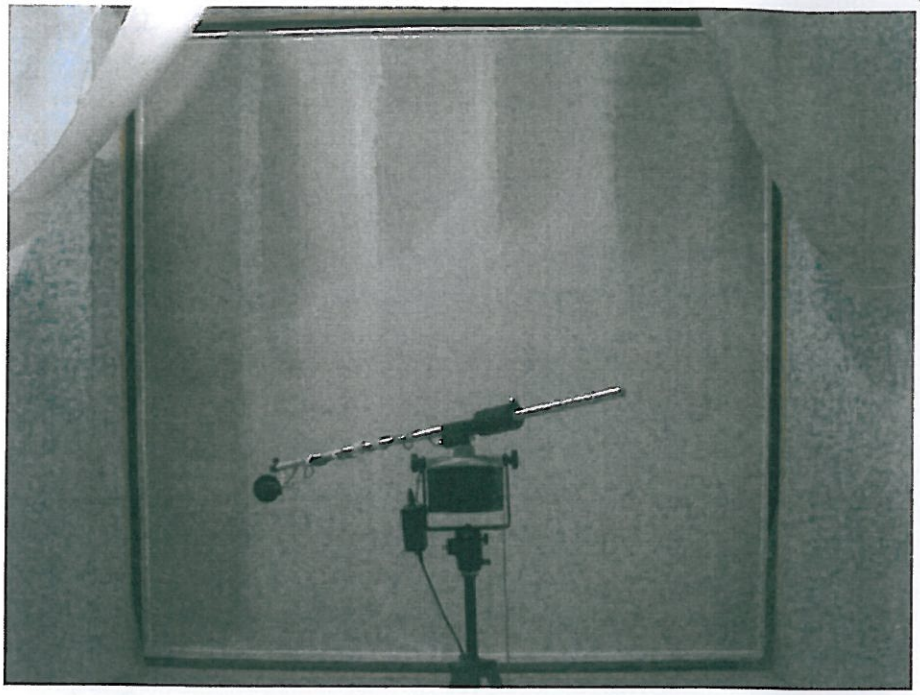


Figure 2 : Test setup in Source Room

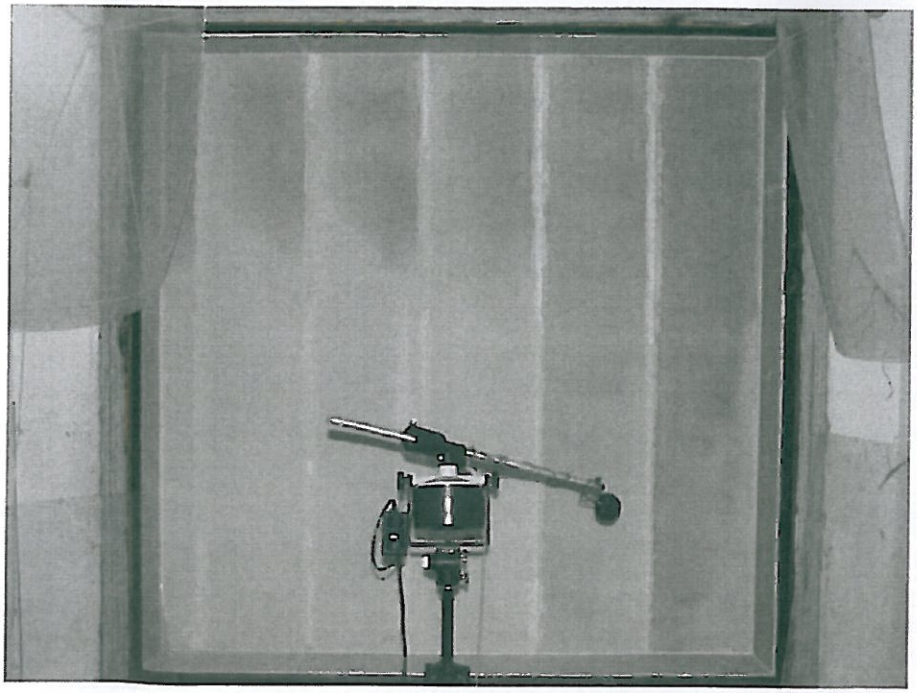
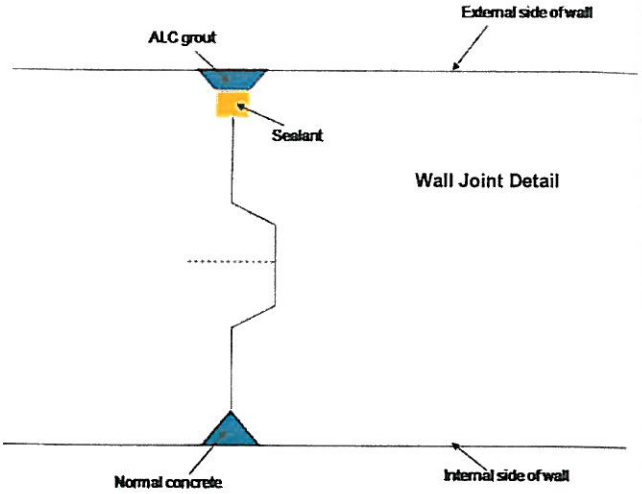
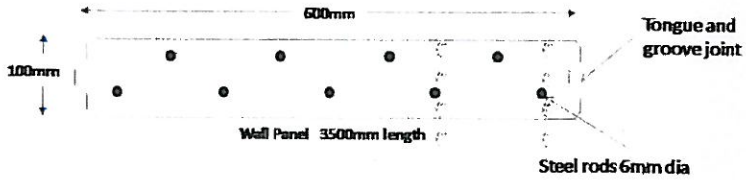


Figure 3 : Test setup in Receiving Room





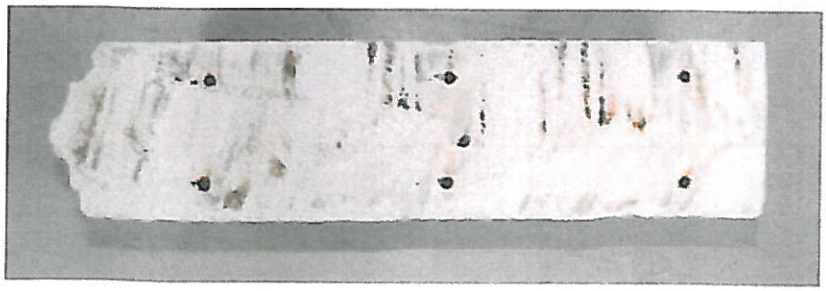


Figure 4 : Joint Detail and Cross Section of ALC wall panel

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8. Nothing in this report shall be interpreted to mean that TÜV SÜD PSB has verified or ascertained any endorsement or marks from any other testing authority or bodies that may be found on that sample.

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May 2007

e) Partition Performance Test Report

Test Report No. S08MEC00402/TWL
dated 31 Dec 2007

Note: This report is issued subject to TÜV SÜD PSB's "Terms and Conditions Governing Technical Services". The terms and conditions governing the issue of this report are set out as attached within this report.

PARTITION PERFORMANCE

OF

AUTOCLAVED LIGHTWEIGHT CONCRETE (ALC)

WALL PANEL

TESTED FOR: GISS Pty Ltd (ACN 125 794 649)
Gr Flr, 2 Mill Street
Perth, WA 6000
Australia

PREPARED BY: Tay Wei Liang
Associate Engineer

APPROVED BY: Raymond Tan
Senior Engineer
Building & Industrial Products,
Testing Group

PSB TEST
Your Peace of Mind

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Co. Reg : 199002667R

Regional Head Office:
TÜV SÜD Asia Pacific Pte. Ltd.
3 Science Park Drive
#04-01/05 The Franklin
Singapore 118223

SUMMARY

TESTED FOR	GISS Pty Ltd
TEST SAMPLE PANEL	Autoclaved Lightweight Concrete (ALC) Wall Panel with thickness of 100mm
TEST DATE	10 Dec 2007 to 31 Dec 2007
TEST METHOD	SS 492 : 2001 & BS 5234 Part 2 : 1992
TEST DESCRIPTION	The purpose of the test is to determine the resistance to damage of partition system for use as internal walls of buildings.

Tests for grade compliance:

a. Stiffness	Load of 500N applied through an area of 150 mm diameter plate perpendicular to the partition surface. 10 mm maximum deflection allowable.
b. Small hard body impact	Impact by a 50 mm diameter / 3 kg steel ball with a swinging arm of 600 mm long swung perpendicularly against the wall. Test on 11 positions (includes a corner). Criteria: no significant damage.
i. Surface damage	Impact energy of 10 Nm (swing angle of 63.6 degree)
ii. Perforation	Impact energy of 30 Nm (swing angle of 131.8 degree)
c. Large soft body impact	Impact by a 50 kg spheroconical bag of 600 mm X 400 mm diameter filled with hardened glass beads. Test on 3 positions (includes a corner). Criteria: no significant damage.
i. Resistance to damage	Impact energy of 100 Nm (drop height of 204 mm). Single impact at two selected positions and one on corner.
ii. Resistance to structural damage	Impact energy of 120 Nm (drop height of 245 mm). Three impacts at two selected positions.
d. Door slam	Partition wall is being slammed a hundred times with a 60 kg door leaf by a force of 15 kg. Door frame shall not be permanently displaced by 1mm.

Other tests:

a. Crowd pressure	A load of 3.0 kN/m is applied through a 2.5 m wooden beam at a height of 1.2 m. No damage or collapse that would render the partition dangerous be allowed.

SUMMARY OF TEST RESULTS:

Summary of strength and robustness tests to SS492 :2001 & BS 5234 : Part 2 : 1992 (Details of partition specimen and test report are attached)				
Tests for grade compliance				
Requirements tested	Grade performance achieved Pass/Fail			
	LD	MD	HD	SD
Stiffness	-	-	-	Passed
Surface damage by small hard body impact : [1]				
Straight partition	-	-	-	Tested
Right angle partition	-	-	-	Tested
Surface damage by large soft body impact:				
Straight partition	-	-	-	Passed
Right angle partition	-	-	-	Passed
Perforation by small hard body impact: [1]				
Straight partition	-	-	-	Passed
Right angle partition	-	-	-	Passed
Resistance to structural damage by large soft body impact	-	-	-	Passed
Door slamming	-		-	Passed

Summary of other tests on partition specimen	
Requirement tested	Performance achieved
Crowd pressure	3.0 kN/m

TABLE OF CONTENTS

1. INTRODUCTION

This document describes the test procedures and reports the performance of partition system.

2. DESCRIPTION OF SAMPLE

The following components information were supplied by GISS Pty Ltd.

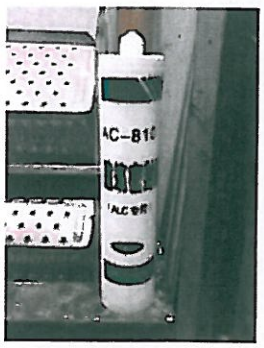
Project Name: GISS

Panel Name: Autoclaved Lightweight Concrete (ALC) Wall Panel (without finishing)

Components:

1) Screw used in mock-up of partition wall system : M12 Grad 4.6 bolt

2) Jointing compound (wall) :
- ALC Grout
- AC-810 Sealant
- construction concrete mix



3. TEST STANDARD

BS 5234: 1992 "Partitions (including matching linings)
Part 2: Specification for performance requirements for strength and robustness including methods of test"

4. TEST SETUP

A mock-up test specimen 4.8 m length X 3.0 m height and a partition junction assembly of a right-angle corner with a return of 1.2 m were installed onto the test rig for the performance test.

A total of 2 sheet of attached company's drawings contain the details of the mock-up specimen.

The test specimen includes a doorset 0.84 m width X 2.16 m height and a 0.59 m run of partition flanking at one side of the doorset.

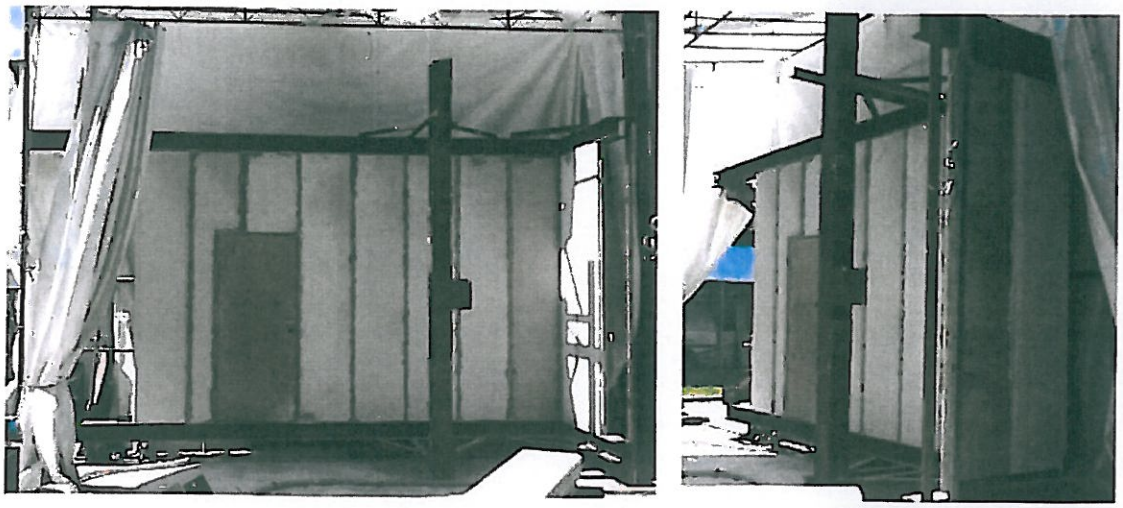


Figure 1: Full Test specimen mock-up

5. DESCRIPTION OF TESTS

The following tests were conducted:

i. Partition stiffness

ii. Small hard body impact
   a. Surface damage
   b. Perforation

iii. Large soft body impact
   a. Resistance to surface damage
   b. Resistance to structural damage

iv. Door slam

v. Crowd pressure

5.1 Partition stiffness

This test is to establish the ability of the partition to withstand people or ladder leaning against the partition wall without causing unacceptable cracking or movement.

A static horizontal load of 500 N was applied through a 150 mm diameter steel plate with a contact rubber pad of 6 mm thick. The load was applied to the partition at a height of 1500 mm from the bottom of the setup. Deflection was taken on the load side at 125 mm above the centre point of load application. A pretest load of 100 N was applied and stabilised for 1 min before unloading. The load was then applied in steps of 100 N until 500 N before unloading. Each loading was maintained for about 2 minutes for stabilisation.

Deflection was taken at the end of the 2 minutes interval. The residual deflection was taken 1 hour after unloading.

5.2 Small hard body impact

The test is to simulate impact caused by sharp or pointed objects such as trolleys and wheelchairs. A 3 kg / 50 mm diameter steel sphere impactor was used to simulate a hard body object. It was attached to a 600 mm long swinging arm.

5.2.1 Surface damage

This test is to determine the resistance of the partition to damage from impacts by small, hard body objects.

Ten positions on the main wall of the test setup were chosen for the test. Each position was subject to a 10 Nm impact energy. The swinging arm was raised by 0.33 m or an angle of 63.6 degree and released. The rebounce of the steel arm was withheld to prevent it from making a second impact.

The depth of indentation was taken after each impact for a position.

The test was repeated at a corner position 75 mm away from the corner edge.

5.2.2 Perforation

This test is to determine the resistance of the partition to perforation from impacts by small, hard objects.

Ten positions on the main wall of the test setup were chosen for the test. Each position was subject to a 30 Nm impact energy. The swinging arm was raised by 1 m or 131.8 degree and released. The rebounce of the steel arm was withheld to prevent it from making a second impact. The partition was inspected for any damage or perforation.

The test was repeated at a corner position 75 mm away from the corner edge.

5.3 Large soft body impact

The test is to simulate impact caused by people falling against or any large soft body object such as a ball hitting the partition wall. The impactor is a spheroconical bag of 600 mm X 400 mm filled with hardened glass beads. It has a total weight of 50 kg.

5.3.1 Resistance to surface damage

Two positions on the parititon wall were selected for the test. Each location was subject to a single swinging impact. A linear gauge was placed behind the impacted panel to measure the permanent deformation.

The impact energy was 100 Nm. The impactor was raised by 204 mm before releasing. Permanent deformation was taken after 5 minutes from the impact.

The test was repeated at a corner position 200 mm away from the corner edge.

5.3.2 Resistance to structural damage

Two positions on the partition wall were selected for the test. Each location was subject to three swinging impacts.

The impact energy was 120 Nm. The impactor was raised by 245 mm before releasing. The partition was inspected for any surface or structural damage.

5.4 Door slam

The test simulates a door being forcefully slammed by a person, wind or tensioned door closer.

A 60 kg door leaf was slammed through an opening angle of 60 degrees with a force of 15 kg for 100 times. Residual deflection was taken on the door frame at 1 m above the bottom of the door leaf after 5 minutes from the last slamming.

5.5 Crowd pressure

This test simulates a uniform band load such as a crowd leaning against the wall.

A test load of 3.0 kN/m was applied through a 2.5 m long wooden beam placed at a height of 1.2 m above the bottom of the wall. Deflection was taken at 125 mm above the beam. Residual deflection was taken after 5 minutes upon released of the load.

6. TEST RESULTS

6.1 Partition stiffness

Date of test: 28 Dec 2007
Lab temperature: 28.0 °C

Load (N)	Duration (min)	Deflection (mm)	Residual Defection (mm)	Condition of the specimen tested
Pretest load of 100 N	1	-0.11	-0.01	No damage was observed.
100	2	-0.10	-	
200	2	-0.19	-	
300	2	-0.30	-	
400	2	-0.41	-	
500	2	-0.52	-0.07	

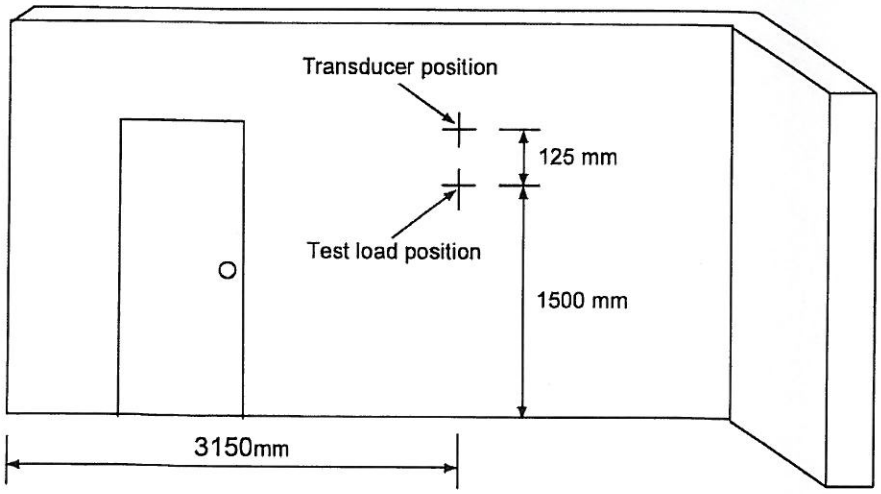


Figure 2: Location of applied load for partition stiffness test

6.2 Small hard body impact

6.2.1 Surface damage

Date of test : 27 Dec 2007
Lab temperature: 29.0 °C
Impact Energy : 10 Nm

Impact Position	Y (mm)	X (mm)	Depth of indentation (mm)	Condition of the specimen tested
1	430	2120	2.5	No damage or dislodgement of partition was observed.
2	750		2.7	
3	1050		3.3	
4	1250		3.5	
5	730	2630	2.3	
6	1250		3.5	
7	1840		3.5	
8	520	4320	2.3	
9	980		2.8	
10	1380		3.4	
**11	1000	75	2.9	

**Note: Corner junction

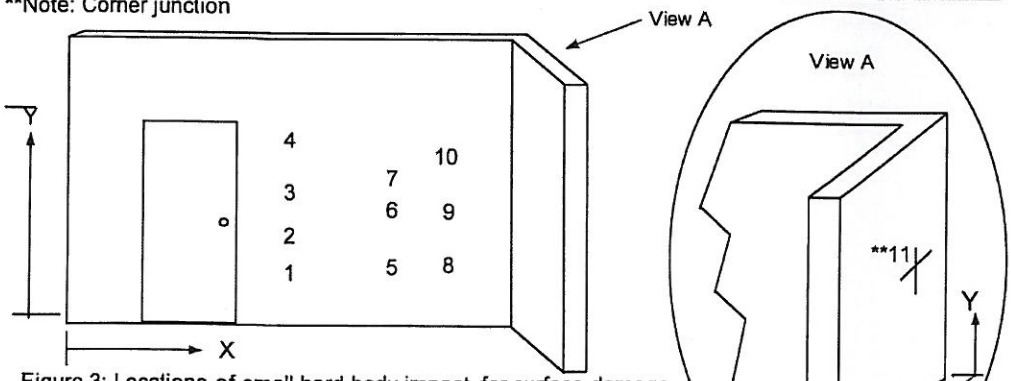
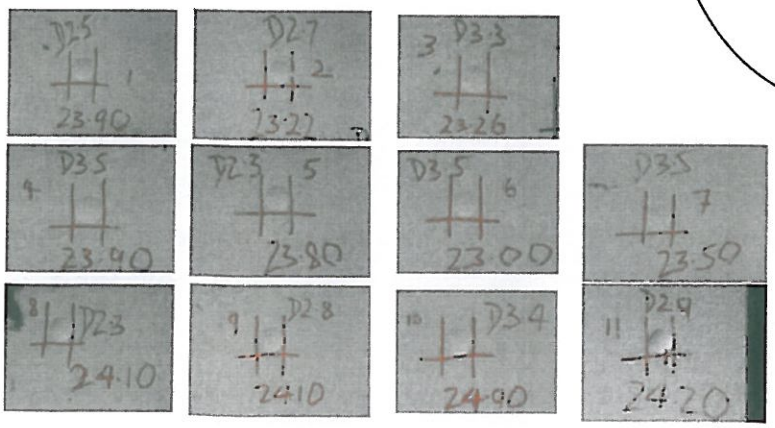


Figure 3: Locations of small hard body impact for surface damage



6.2.2 Perforation

Date of test: 27 Dec 2007
Lab temperature: 29.0°C
Impact energy : 30 Nm

Impact Position	Y (mm)	X (mm)	Depth of indentation (mm)	Condition of the specimen tested
1	610	2220	4.1	No damage or dislodgement of partition was observed.
2	1030		5.6	
3	1350		7.1	
4	1550		7.9	
5	520	2570	5.2	
6	1030		6.5	
7	1710		7.7	
8	620	4360	5.4	
9	1180		7.1	
10	1630		6.8	
**11	1370	75	6.2	

**Note: Corner junction

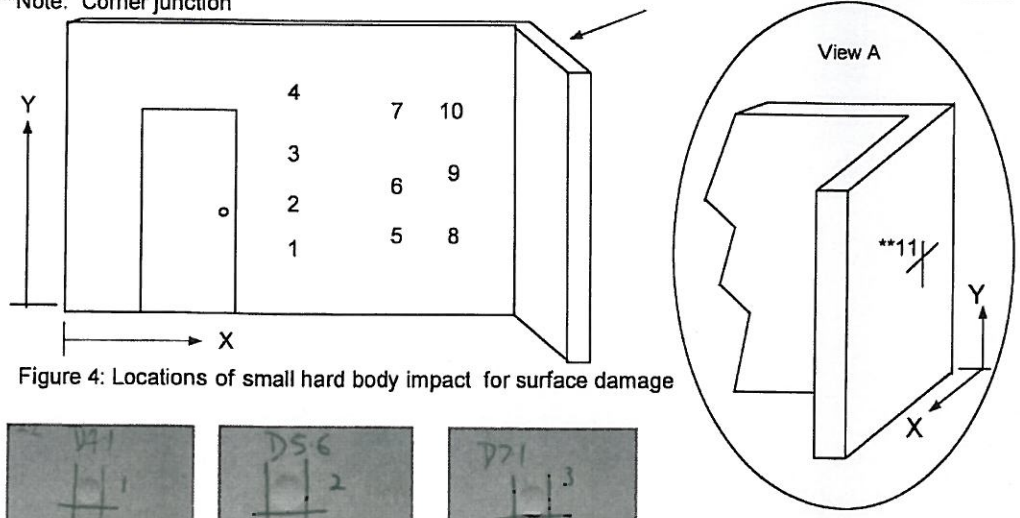
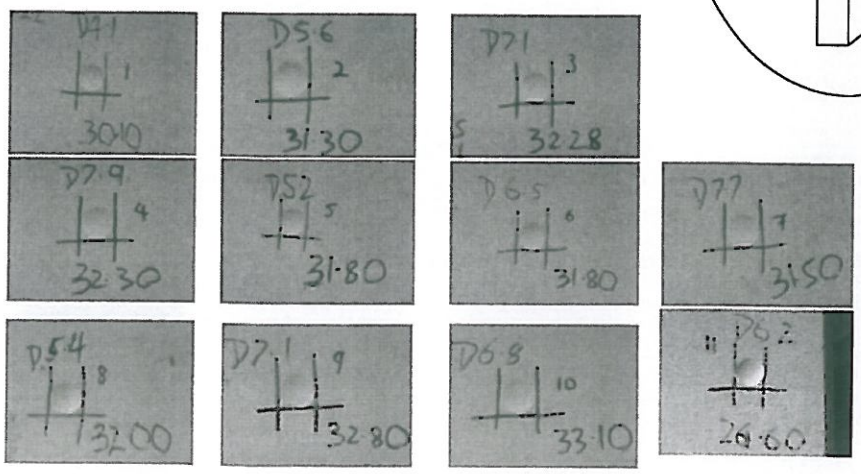


Figure 4: Locations of small hard body impact for surface damage



6.3 Large soft body impact

6.3.1 Resistance to damage

Date of test : 27 Dec 2007
Lab temperature: 28.5 °C
Impact Energy: 100 Nm

Impact Position	Y (mm)	X (mm)	Residual deflection (mm)	Condition of the specimen tested
1	1500	2600	0.1	No damage observed.
2	1570	3930	0.1	
**3	1245	200	0.0	

**Note: Corner junction

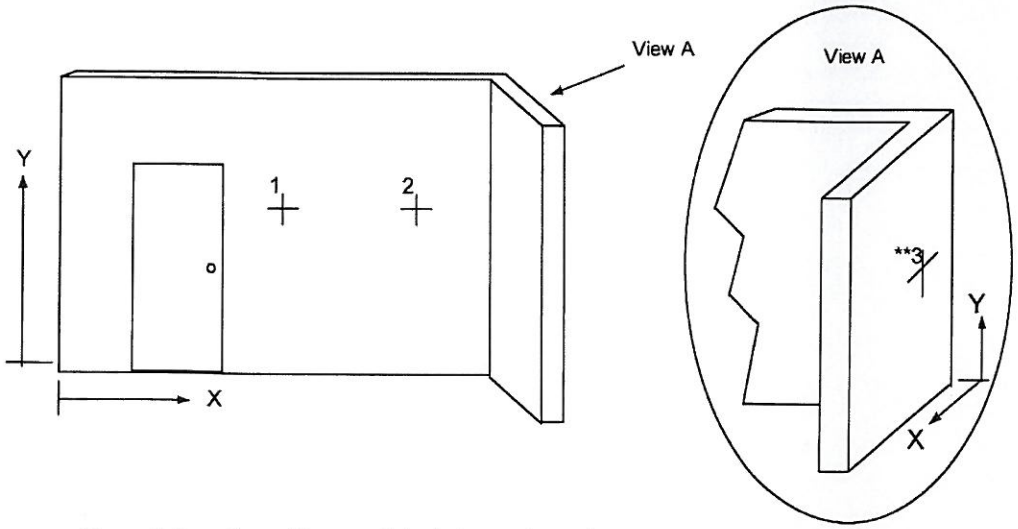


Figure 5: Locations of large soft body impact for resistance to damage

6.4 Door Slaming

Date of test : 26 Dec 2007
Lab temperature: 29.0 °C

Open door to 60° ± 1° (Number of slam)	Residual deflection (mm)	Condition of the specimen tested
Pretest of 3	-0.60	No damage was observed
100	-0.76	

6.5 Crowd Pressure

Date of test : 28 Dec 2007
Lab temperature: 29.5 °C

Load	Duration (min)	Deflection (mm)	Residual Deflection (mm)	Condition of the specimen tested
Pretest load of 200 (N)	1	-0.11	-0.02	No crackline or damage was observed.
3.0 KN/M	2	-4.87	-0.12	

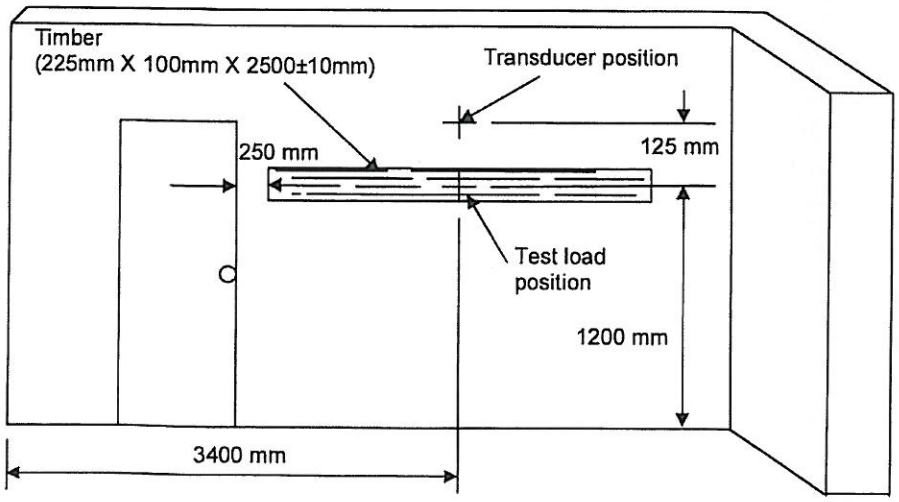


Figure 7: Locations of applied load for crowd pressure

7. CONCLUSION

The partition system meets the severe duty grade requirements of SS492 :2001 & BS 5234 Part 2: 1992.

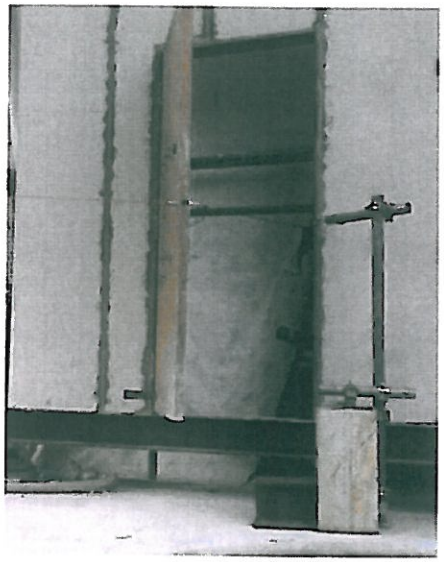
The partition system has also achieved the following performance:

Crowd pressure	:	3.0 kN/m

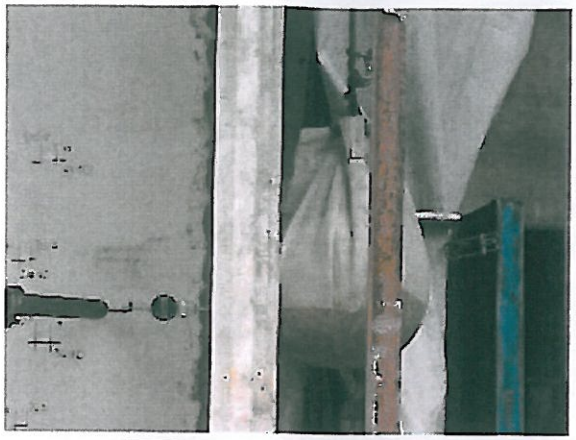
Tay Wei Liang
Associate Engineer

Raymond Tan
Senior Engineer
Building & Industrial Products
Testing Group

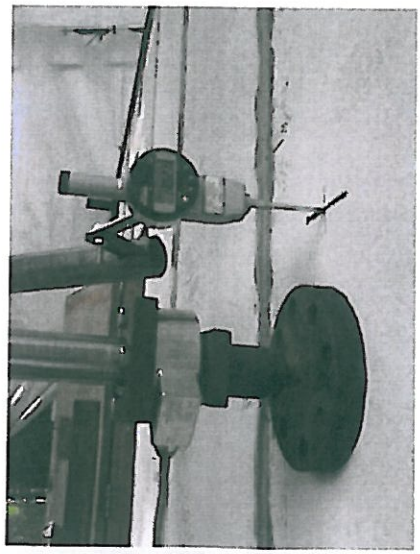
APPENDIX: TEST SET-UP



Door Slamming Test



Large Soft Body Impact – Resistance to Damage



Stiffness Test

Crowd Pressure Test

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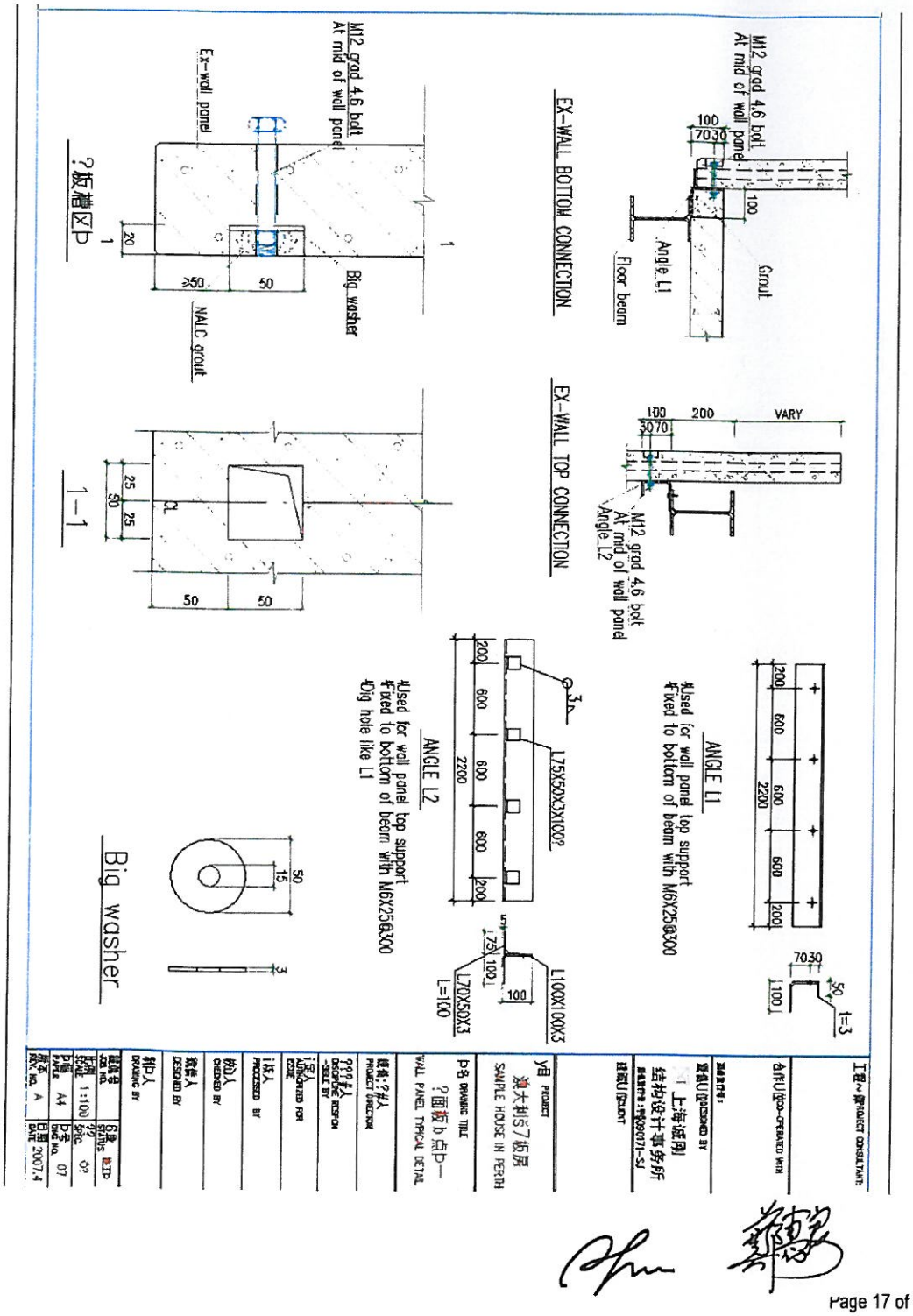
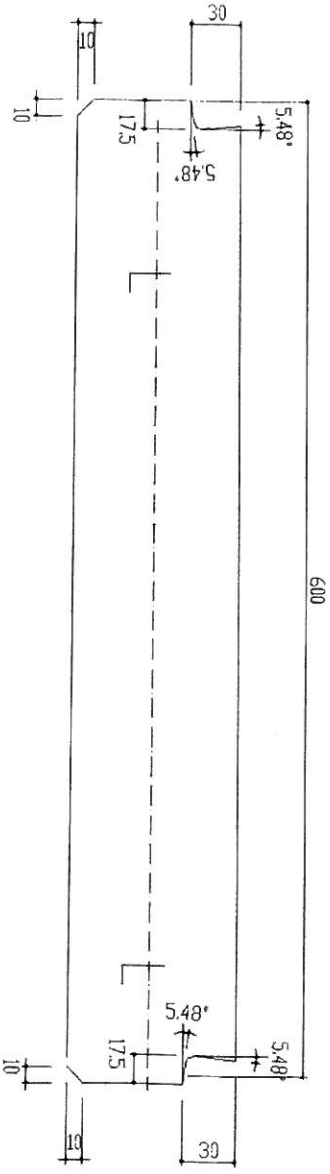
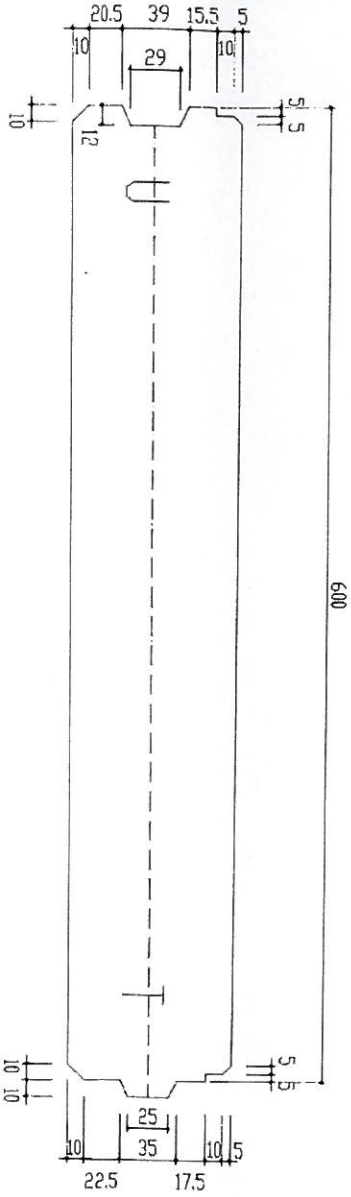


The following drawing informations were supplied by GISS Pty Ltd.





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3. This report applies to the sample of the specific product/equipment given at the time of its testing/calibration. The results are not used to indicate or imply that they are applicable to other similar items. In addition, such results must not be used to indicate or imply that TÜV SÜD PSB approves, recommends or endorses the manufacturer, supplier or user of such product/equipment, or that TÜV SÜD PSB in any way "guarantees" the later performance of the product/equipment.
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May 2007

5.0 PART C

BESTA BOARD PANEL

5.1 DESCRIPTION

5.1.1 General Description of the Product

Besta Board Panel is a newly developed and upcoming green material to be used for dry construction. This product has special characteristics which include fire, water and mold resistant as well as having high impact strength. Therefore, it is suitable for interior, exterior and sheathing applications in construction.

5.1.2 Usage and Application of the Product

Besta Board Panel has been used as finishing materials to walls and ceiling in offices, shopping centres, private apartments, condominiums, airport, hotels, schools, hospitals, etc. Some patterned products have been selected and used as decorative boards.

5.1.3 Element of the Product

Magnesium Oxide (MgO_2) which is new inorganic – bonded composite.

5.1.4 Usage Limitation

Under normal condition or environment, there is **no** limitation. The panel is for non load bearing application. The limitation of the storey of the building that can be constructed using this Besta Board Panel was not shown.

5.1.5 Manufacturing Process

This product is a factory made product. This board is produced with alkali-resistant fiberglass mesh as strengthened material. MgO_2 with melting point of 2800°C is often used as a basic refractory material for lining crucibles and furnaces. During the manufacturing process, no energy is consumed since the entire process is completed at room temperature. All manufacturing excess may be reground and reused for subsequent production.

5.1.6 Technology and Skilled Required

Based on the documents received, the technology of this product relies on the raw materials and the manufacturing process. Special technology and skilled are not required. The design and manufacturing are supervised by the experienced labour to ensure the straightness, flatness and water tightness.

5.2 BASIS OF APPRAISAL

5.2.1 Document Received from Well & Able (M) Sdn Bhd (WASB)

The following documents were received to support the appraisal of the product.

i. Documents on the details and description of the product

ii. Test report on the material, product and performance

5.2.2 Technical Visit

No technical visit has been made.

5.3 MATERIAL: SPECIFICATIONS AND TESTS

5.3.1 Specifications

i. Product Range

Besta Board Panel comes as standard white colour. Standard production material is very smooth on one side and sand texture on the other.

Besta Board Panel complements all paints types, and may be wallpapered or tile with ease.

Standard edges are squared or tapered. Special edges and sizes can be specified at the manufacturing process. It may be cut trimmed or shaped using basic power or hand tools. The detail about Besta board prduct range is shown in Appendix C1.

5.3.2 Types of Testing

A series of test has been carried out by other parties that have related product with WASB (Please refer Section 10.1). These tests are performed to determine the performance of the product. The types of test are listed below :

i. Test on material

For the material, the physical and mechanical properties tests have been done. The test results were obtained and the official report is attached in Appendix C2.

a. Density

b. Bending strength (dry & saturated)

c. Linear thermal shrinkage

d. Moisture movement

e. Water absorption

f. Moisture content

g. Water tightness

ii. Test on product

The test that have been performed on this product are as below :

a. Fire resistance test

- Fire resistance test on a Non Load Bearing Besta Board Panel
- Fire resistance test on a Non-Load Bearing Besta Board Panel
- Non-combustibility test on Besta Fire Resistant Board material

b. Thermal conductivity test

c. Sound insulation test

- Measurement of airborne sound transmission loss of Besta Board Panel system
- Measurement of airborne sound insulation of Besta Board Panel system
- Measurement of impact sound insulation of Besta Board Panel system

d. Performance test (strength & robustness) on Besta Board Panel system

5.3.3 Additional Tests Required

The Applicant is to notify to the Technical Expert Panel on any additional test required (if any) by fabricator or client.

5.3.4 Check on Test Report Provided by WASB

i. Test on material

The summary of the tests done and the results are shown in Table 9. The details of the test report are attached in Appendix C2.

Table 9 : The summary of the tests results

Type of test	Result
Physical and Mechanical Properties Test Report (Dated : 19th September 2008) *(for official test report, please refer to Appendix C2 : a (page 122- page 142)*	
i. Besta Board Panel with thickness of 16 mm *(page 122- page 132)* (cut to the required size)	
a. Density	1030 kg/m^3
b. Bending strength (Dry and saturated)	10.1 N/mm^2 (Dry) ; 9.5 N/mm^2 (Saturated)
c. Linear thermal shrinkage	-2.2%. -0.1%,0.5%, 1.7% and 2.3% 0.211%
d. Moisture movement	21.6 %
e. Water absorption	7.5 %
f. Moisture content	No sign of water droplet or dampness formed on the bottom surface of all test specimens was observed after 24 hours
g. Water tightness	
ii. Besta Board Panel with thickness of 10 mm *(page 133- page 142)* (cut to the required size)	
a. Density	1060 kg/m^3
b. Bending strength (Dry and saturated)	5.1 N/mm^2 (Dry) ; 6.2 N/mm^2 (Saturated)
c. Linear thermal shrinkage	Samples softened & crumpled after subjected to 950 °C for 4 hours 0.076%
d. Moisture movement	22.0 %
e. Water absorption	9.6 %
f. Moisture content	Dampness appeared after 5 hours
g. Water tightness	

ii. Test on product

The summary of the tests done and the results are shown in Table 10. The official test reports are attached in Appendix C2.

Table 10 : The test summary of tests result

Type of test	Result
Fire Resistance Test *(for official test report, please refer to Appendix C2 : b (page 143- page 142)*	
i. Fire resistance test on a non load bearing (Dated : 15th September 2008) *(page 143- page 159)* a. Loss of Integrity Failure shall be deemed to have occurred when one of the following occurs : • When collapse or sustained flaming for more than 10 seconds on the unexposed face. • When the cotton pad test is conducted, flames and/or hot gas causing flaming or glowing of the cotton pad • Where the cotton pad test cannot be conducted because of the level of radiation from the specimen, a through gap into furnace exceeding 6mm in width by 150 mm in length exist or develops in the specimen. • When a through gap into furnace exceeding 25mm diameter exists or develops in the specimen. b. Insulation Failure shall be deemed to have occurred when one of the following occurs : • If the mean unexposed face temperature increases by more than	The specimen satisfied the requirements of the BS 476 : Part 22 : 1987 for period stated below : Integrity : 199 minutes At 200 minutes of heating, a 6mm gap gauge was employed at through gap between panel C and D and was able to traverse vertically for 200mm. Therefore, the integrity of the Besta board panel meets the standard for 199 minutes. Insulation : 164 minutes At 165 minutes of test, the maximum mean temperature rise and maximum temperature rise above initial

140 °C above its initial value. • If the temperature recorded at of any position on the unexposed face is in excess of 180 °C above the initial mean unexposed face temperature. • When integrity failure occur.	temperature on the unexposed face of specimen were 95.3 °C and 190.2 °C respectively. Therefore, the insulation of the Besta board panel meets the standard for 164 minutes.
ii. Fire resistance test on a non load bearing 75mm thick Besta board panel drywall partition system (Dated : 14th June 2010) *(page 160- page 180)* a. Loss of Integrity Failure shall be deemed to have occurred when one of the following occurs : • When collapse or sustained flaming for more than 10 seconds on the unexposed face. • When the cotton pad test is conducted, flames and/or hot gas causing flaming or glowing of the cotton pad • Where the cotton pad test cannot be conducted because of the level of radiation from the specimen, a through gap into furnace exceeding 6mm in width by 150 mm in length exist or develops in the specimen. • When a through gap into furnace exceeding 25mm diameter exists or develops in the specimen. b. Insulation Failure shall be deemed to have occurred when one of the following occurs : • If the mean unexposed face temperature increases by more than	The specimen satisfied the requirements of the BS 476 : Part 22 : 1987 for the periods stated below : Integrity : 128 minutes Integrity failures at 128 minutes 09 seconds of test where continuous flaming for more than 10 seconds at clearance between board butt joint about 150 mm above mid height, 560 mm from the fixed edge was seen. Therefore, the integrity of the drywall partition meets the standard for 128 minutes. Insulation : 97 minutes At 97 minutes of test, the maximum mean temperature rise and maximum

140 °C above its initial value. • If the temperature recorded at of any position on the unexposed face is in excess of 180 °C above the initial mean unexposed face temperature. • When integrity failure occur.	temperature rise above initial temperature on the unexposed face of specimen were 74.8 °C and 177.1 °C respectively. At 98 minutes of test, the maximum temperature rise above initial temperature was 182.1 °C, which exceeded the maximum permissible temperature of 180 °C. Therefore, the insulation of the drywall partition meets the standard for 97 minutes.
Non-combustibility test on Besta board panel – Fire resistance board material (Dated : 30th September 2008) *(page 181- page 183)* To determine whether the material is non-combustible when it exposed to the conditions of the test specified in BS 476 : Part 4 : 1970 " Fire Test on Building Materials and Structures – Non-combustibility Test for Materials".	The classification of the material is non-combustible.
Thermal Conductivity Test *(for official test report, please refer to Appendix C2 : c (page 185- page185)* (Dated : 19th September 2008)	Please refer to official test report for detail results
Sound Insulation Test *(for official test report, please refer to Appendix C2 : d (page 187- page 218)*	
i. **Laboratory measurement of airborne sound transmission loss of Besta board panel system** (Dated : 8th August 2008) *(page 187- page 193)*	The tested Besta board panel achieved sample has a sound transmission class, STC = 36. Sound Insulation rating was computed according to ASTM E413-04 "Classification of rating sound insulation".

ii. Laboratory measurement of airborne sound insulation of Besta board panel system (Dated : 8th August 2008) *(page 194- page 201)*	The tested Besta composite mineral board achieved a weighted sound reduction index, R_w (C,Ctr) = 36 (0,-2). Sound Insulation rating was computed according to ISO 717-1:1996 "Acoustics-Rating of sound insulation in building and of building elements-Part 1: Airborne sound insulation
iii. Laboratory measurement of impact sound insulation of Besta board panel system (Dated : 12th August 2008) *(page 202- page 217)*	The tested Besta board panel system achieved a Weighted Normalised Impact Sound Pressure Level, $L_{n,w}$ = 86 (C_1=-9)
Performance Test (Strength and robustness) *(for official test report, please refer to Appendix C2 : e (page 218- page 239)* (Dated : 19th September 2008)	
i. Determination of partition wall stiffness – Annex A	No damage occurred to other parts of the surface during and after the test.
ii. Surface damage by small hard body impact – Annex B	No damage occurred to the other parts of the surface during and after the test.
Iii. Resistance to damage by impact from a large soft body – Annex C	No damage occurred during and after the test. Criteria of SS 492 : 2001 : 2mm maximum deformation.
iv. Resistance to perforation by small hard body impact – Annex D	No damage occurred to the other parts of the surface during and after the test. Criteria of SS 492 : 2001 : No perforation of facing.
v. Resistance to structural damage by impact from a large soft body – Annex E	No damage, collapse or dislocation occurred during

	and after the test. Criteria SS 492 : 2001 : No collapse or dislocation.
vi. Effect of door slamming – Annex F	No durface or structural damage, detachment, loosening or dislodgement of any parts of fittings or trims during and after the test. Criteria of SS 492 : 2001 : No damage and 1mm maximum displacement.
vii. Resistance to crowd pressure–Annex G	No collapse or damage occurred during and after the test. Criteria of SS 492 : 2001 : No collapse or dangerous.
viii. Lightweight anchorage pull-out - Annex H	No damage occurred during and after the test. Pull-up shims plate was not released throughout the test. Criteria of SS 492: 2001: Shin retained.
ix. Lightweight anchorage pull-down - Annex J	The pull-up shim plate retained and maximum displacement less than 2mm (0.26mm) at the load of 250 N. Criteria of SS 492: 2001: Shim retained and 2mm maximum displacement
x. Heavyweight anchorage (wash basin) eccentric downward loading – Annex K	Shim plate intact but gaps between bracket and wall were noted, a fine crack also found the top left anchorage point after the test/ dislodgement of its parts or fixing after the test.
xi. Heavyweight anchorage (high level wall cupboard) eccentric downward loading – Annex L	Criteria of SS 492: 2001: 15mm maximum deflection and 1mm maximum residual.

iii. Test on performance of the product

The summary of test results on strength and robustness according to SS 492 : 2001/ BS 5234 : Part 2: 1992 and its results are shown in Table 11 below :

Table 11 : The summary of test results on strength and robustness

Test For Grade Compliance Requirement tested	BESTA MgO board sandwich wall panel (10mm board + 80mm perlite + 10 mm board) system			
	Grade Performance Achieved : Pass/Fail			
	LD	**MD**	**HD**	**SD**
Stiffness (Annex A)	-	-	-	Pass
Surface Damage by Small Hard Body Impact (Annex B) :	-	-	-	
Straight Partition	-	-	-	Tested*
Right-angle Junction	-	-	-	Tested*
Resistance to Damage by Large Soft Body Impact (Annex C) :	-	-	-	
Straight Partition	-	-	-	Pass
Right-angle Junction	-	-	-	Pass
Perforation by Small Hard Body Impact (Annex D) :	-	-	-	
Straight Partition	-	-	-	Pass
Right-angle Junction	-	-	-	Pass
Resistance to Structural Damage by Large Soft Impact (Annex E)	-	-	-	Pass
Door slamming	-	-	-	Pass
Grade Achieved	Passed SD			
Other Test Performed				
Resistance to Crowd Pressure (Annex G)	Up to 3kN/m			
Lightweight Anchorage- Pull-out (Annex H)	Pass			
Lightweight Anchorage- Pull-down (Annex J)	Pass			
Heavyweight Anchorage- Wash Basin (Annex K)	Up to 1000N			

Heavyweight Anchorage- Wash cupboard (Annex L)	2000N

According to SS 492: 2001/ BS 5234: Part 2: 1992, the categorisation of performance are mentioned in Table 12 :

Table 12 : The categorisation of performance according to SS 492: 2001/ BS 5234: Part 2: 1992

Grade	Category of duty	Examples
Light duty (LD)	Small chance of impact	Domestic accommodation
Medium duty (MD)	Some chance of accident occuring	Office accommodation
Heavy duty (HD)	Chances of impact load	Public circulation area[1]
Sever Duty (SD)	Prone to vandalism and abnormally rouge use	Major circulation area[2]

Note [1] : Industrial area [2] : Heavy industrial area

5.4 COMPLIANCE TO INTERNATIONAL STANDARDS OR EQUIVALENT

For the tests on material, the test done was adopted with international standards or equivalent. The standards adopted are shown in Table 13 below:

i. Test on material

Table 13 shows the test conducted and the standards adopted.

Table 13 : Type of tests and standards adopted

Type of Test	Standard
Physical and Mechanical Properties Test	
Density	**ISO TR 1896 : 1991- Clause 6.3** Technical Report : Products in Fibre-reinforced-Cement-Non Combustible Fibre-reinforced boards of Calsium Silicate or Cement for Insulation and Fire Protection
Bending Strength (Dry & Saturated)	**ISO TR 1896 : 1991- Clause 6.4** Technical Report : Products in Fibre-reinforced-Cement-Non Combustible Fibre-reinforced boards

	of Calsium Silicate or Cement for Insulation and Fire Protection
Linear Thermal Shrinkage	**ISO TR 1896 : 1991- Clause 6.7** Technical Report : Products in Fibre-reinforced-Cement-Non Combustible Fibre-reinforced boards of Calsium Silicate or Cement for Insulation and Fire Protection
Moisture Movement	**Cl. 8 ASTM C 1185** Standard Test Methods for Sampling and Testing Non-Asbestos Fiber-Cement Flat Sheet, Roofing and Siding Shingles, and Clapboards
Water Absorption	**Cl. 9 ASTM C 1185** Standard Test Methods for Sampling and Testing Non-Asbestos Fiber-Cement Flat Sheet, Roofing and Siding Shingles, and Clapboards
Moisture Content	**Cl. 10 ASTM C 1185** Standard Test Methods for Sampling and Testing Non-Asbestos Fiber-Cement Flat Sheet, Roofing and Siding Shingles, and Clapboards
Water Tightness	**Cl. 11 ASTM C 1185** Standard Test Methods for Sampling and Testing Non-Asbestos Fiber-Cement Flat Sheet, Roofing and Siding Shingles, and Clapboards

ii. Test on product

Table 14 depicts the types of test conducted and standards adopted.

Table 14 : Type of test and standards adopted

Fire Resistance Test Report	
Fire Resistance Test on a Non-Load Bearing Besta Wall Panel (submitted by Best Rock Building Systems Pte. Ltd.	**BS 476 Part 22:1987** Method for Determination of th Fire Resistance of Non-loadbearing Element of Construction-Determination of the Fire Resistance of Partition
Fire Resistance Test on a Non-Load Bearing 75mm thick Besta Wall Panel Drywall Partition System (submitted by	**BS 476 Part 22:1987** "Method for Determination of th Fire Resistance of Non-loadbearing

Well & Able international Pte. Ltd.)	Element of Construction-Determination of the Fire Resistance of Partition"
Non-combustibility test on "BESTA" Fire Resistant Board Material submitted by Best Rock Building System Pte Ltd	**BS 476 : Part 4 : 1970** " Fire Test on Building Materials and Structures – Non-combustibility Test Materials
Thermal Conductivity Test Report	
Thermal Conductivity Test	**ASTM C 518-05**
Sound Insulation Test	
Sound Insulation Test : Measurement of Airborne Sound Transmission Loss of Besta Composite Mineral Board System.	**ASTM E90 – 04** Standard Test Method for Laboratory Measurement or Airborne Sound Transmission Loss of Building Partitions and Elements **ASTM E413 – 04** Classification for Rating Sound Insulation
Sound Insulation Test : Measurement of Airborne Sound Insulation of Besta Composite Mineral Board System .	**ISO 140-3:1995** Labaratory Measurements of Airborne Sound Insulation of Building Elements
Sound Insulation Test : Measurement of Impact Sound Insulation of Besta Board Panel System	**ISO 140-6:1998** Labaratory Measurement of Impact Sound Insulation of Floors

iii. Test on performance

Table 15 depicts the performance test on Besta Board Panel.

Table 15 : Type of tests and standards adopted

Performance Test (Strength & Robustness) :Performance testing (Strength & Robustness) on BESTA magnesium oxide (MgO) sandwich panel system, submitted by Best Rock Building Systems Pte Ltd	**SS 492 / BS 5234 : Part 2: 1992** Specification for Performance Requirements for Strength and Robustness (Including Method of Test for Partition Walls"

5.5 APPENDIX C

C1 BESTA BOARD PANEL PRODUCT RANGE

a) Product Range

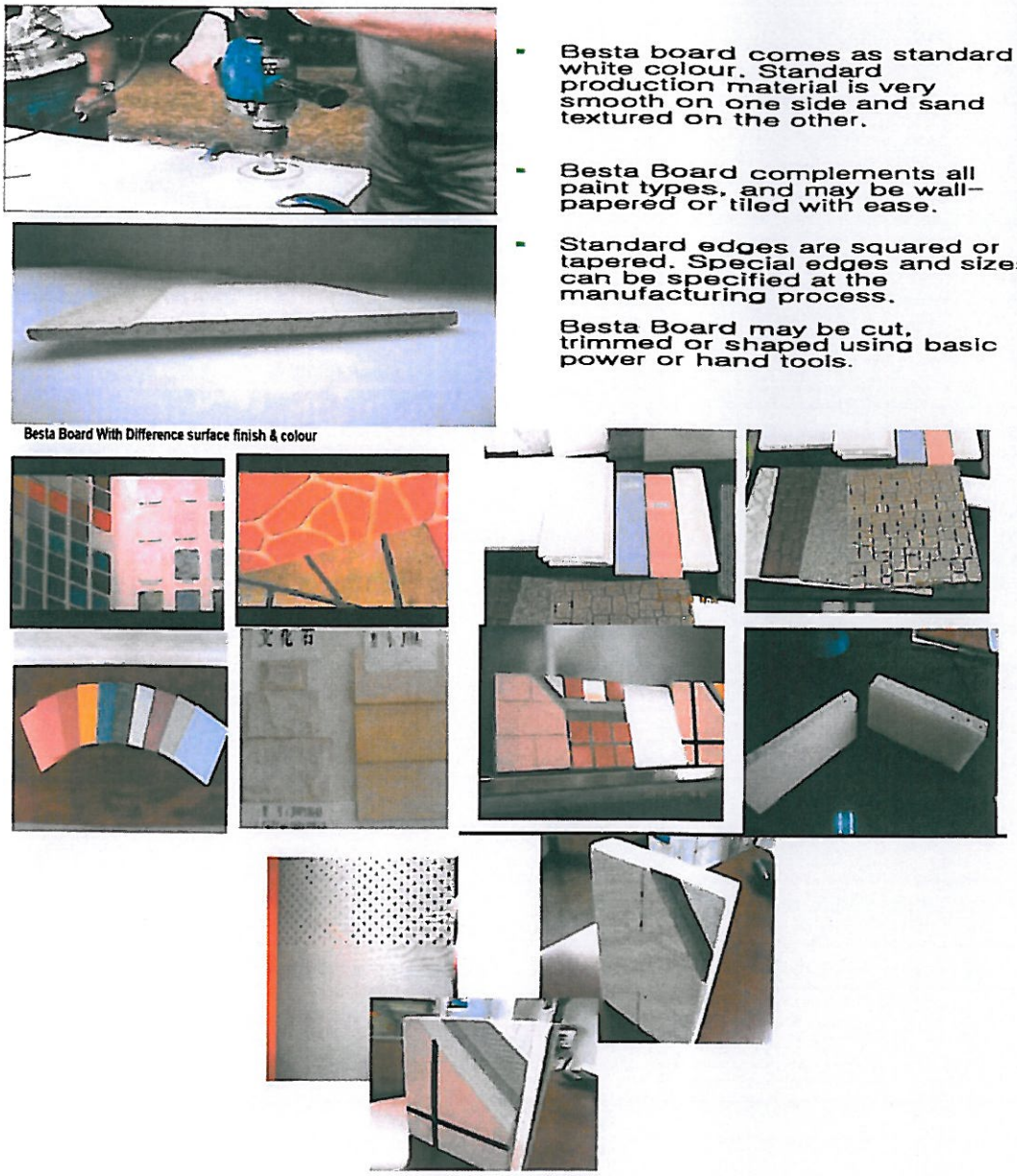

Figure 11 : Besta board product range with difference finish and colour

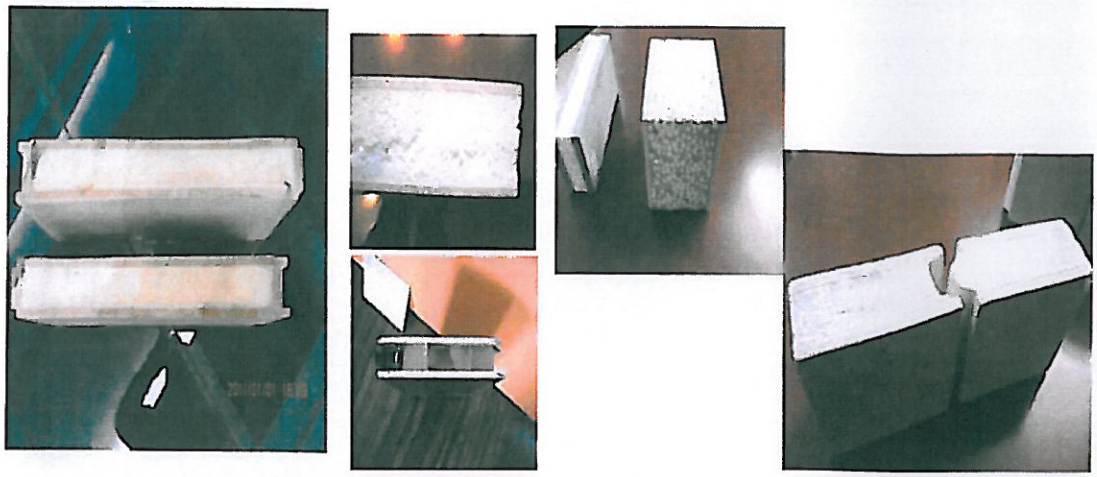

Figure 12 : Besta sandwich panel with difference infill

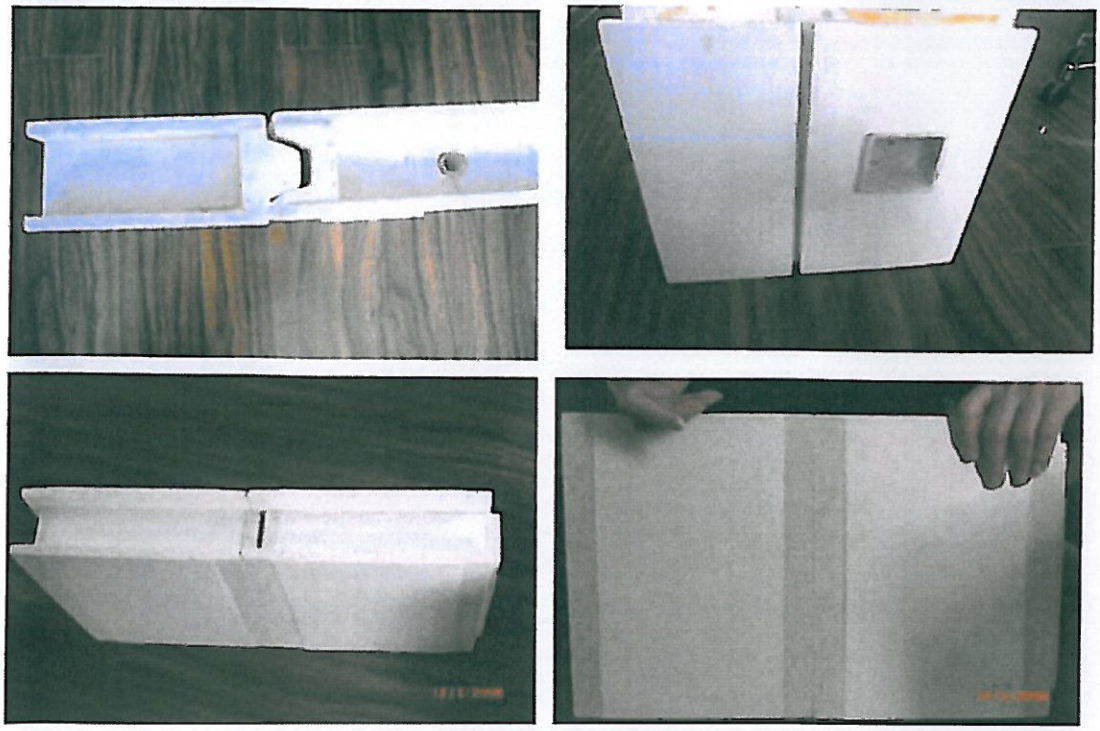

Figure 13 : Besta sandwich panel joint

Job No: SP -2 (2) /THC

Results:

Table 1 : Summary of Test Results on Physical and Meachanical Properties to ISO TR 1896 : 1991 / ASTM C1185

(Test Results on Material Property are attached)

S/N	Type of Test	Clause, Methods	Sample Sizes	Besta MgO Board (16 mm thick)
1	Density	Cl.6.3, ISO TR 1896	60 x 40 x 16 mm	1030 Kg /m³
2	Bending Strength (Dry and Saturated)	Cl.6.4, ISO TR 1896	250 x 250 x 16 mm	10.1 N/mm² (Dry); 9.5 N/mm² (Saturated)
3	Linear Thermal Shrinkage	Cl.6.7, ISO TR 1896	35 x 35 x 16 mm	-2.2%, -0.1%, 0.5%, 1.7% and 2.3%
4	Moisture Movement	Cl.8, ASTM C 1185	305 x 76 x 16 mm	0.211%
5	Water Absorption	Cl.9, ASTM C 1185	100 x 100 x 16 mm	21.6%
6	Moisture Content	Cl.10, ASTM C 1185	152 x 76 x 16 mm	7.5%
7	Water Tightness	Cl.11, ASTM C 1185	610 x 508 x 16 mm	No sign of water droplet or dampness formed on the bottom surface of all test specimens was observed after 24hours.

Results:

Table 2: Density Test

Sample Reference	"BESTA" MgO board (16mm thick)				
	1	2	3	4	5
Date of test	13/11/2008				
Dimension of cut specimen (mm)	60 x 40 x 16mm				
Measured length (mm)	60.5	60.4	60.4	60.5	60.4
Measured width (mm)	40.7	40.7	40.4	40.6	40.8
Measured thickness (mm)	15.3	15.4	15.4	15.3	15.4
Net dry density (kg/m^3)	1030	1020	1030	1020	1040
Mean net dry density (kg/m^3)	1030				

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Results:

Table 3: Bending Strength (Dry and Saturated) Test

Sample Reference	"BESTA" MgO board (16mm thick)							
	Dry strength				Saturated strength			
	1	2	3	4	5	6	7	8
Date of Test	10/11/08							
Dimension of cut specimen (mm)	250 x 250 x 16 mm (thick)							
Distance bewteen supports (mm)	215							
Measured length (mm)	249.8	249.8	249.6	249.4	249.4	249.3	249.6	250.0
Measured width (mm)	249.9	249.8	249.5	249.7	249.3	249.4	249.5	249.8
Thickness measured along the line of fracture - 1st break (mm)	15.3	15.4	15.4	15.5	15.3	15.4	15.4	15.4
Thickness measured along the line of fracture - 2nd break (mm)	15.8	16.0	15.7	15.7	15.5	15.9	15.7	15.5
Mass of specimen after oven dried (g)	1046.0	1044.3	1038.0	1043.9	1034.1	1038.7	1048.3	1053.6
Mass of specimen after immersed in water for 24 hrs pior to test - Oven Dry (g)	-	-	-	-	1243.9	1263.6	1269.5	1255.3
Date of Test	13/11/2008				14/11/2008			
Breaking load -1st break (N)	2086	2288	2049	2218	1916	1864	1870	1943
Breaking load - 2nd break (N)	1540	1340	1525	2018	1763	1609	1663	1524
Bending strength - 1st break (N/mm^2)	11.5	12.5	11.2	12.0	10.5	10.2	10.2	10.5
Bending strength - 2nd break (N/mm^2)	7.9	6.7	8.0	10.6	9.4	8.2	8.7	8.2
Mean bending strength (N/mm^2)	10.1				9.5			

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Results:

Table 4: Linear Thermal Shrinkage Test

Samples Reference	"BESTA" MgO board (16mm thick)				
	1	2	3	4	5
Dimension of cut specimens (mm)	35 x 35 x 16mm				
Date of Test	21/11/2008				
Temperature of furnace for 4 hrs at test	950 °C				
Linear thermal shrinkage %	-2.2	-0.1	0.5	1.7	2.3
Remarks	Crack (See photo 13 Attached)				

Results:

Table 5: Moisture Movement (Linear Change) Test

Sample Reference	"BESTA" MgO board (16mm thick)			
	1	2	3	4
Date of Test	10/11/2008			
Dimension of cut specimens (mm)	305 x 76 x 16 mm			
Length (mm)	305.0	305.1	305.3	305.3
Width (mm)	76.4	76.3	76.3	76.6
Thickness (mm)	15.5	15.3	15.4	15.4
Measurement of specimen after condition at R.H 30%	24.071	24.082	24.297	24.228
Measurement of specimen after condition at R.H 90%	24.135	24.135	24.345	24.266
Linear change %	0.268	0.222	0.198	0.155
Average Linear Change %	0.211			

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Results:

Table 6: Water Absorption Test

Sample Reference	"BESTA" MgO board (16mm thick)									
	1	2	3	4	5	6	7	8	9	10
Date of test	10/11/2008									
Dimension of cut specimens (mm)	100 x 100 x 16									
Length (mm)	100.4	100.6	100.5	100.5	100.5	100.4	100.4	100.5	100.3	100.3
Width (mm)	100.3	100.4	100.5	100.4	100.3	100.4	100.4	100.3	100.4	100.3
Water absorption by mass (%)	21.6	21.1	22.3	22.0	22.4	20.6	21.0	21.3	22.0	21.7
Average water absorption by mass (%)	21.6									

Results:

Table 7: Moisture Content Test

Sample Reference	"BESTA" MgO board (16mm thick)				
	1	2	3	4	5
Date of Test	10/11/2008				
Dimension of cut specimens (mm)	152 x 76 x 16				
Length (mm)	152.2	152.2	152.1	152.2	152.4
Width (mm)	77.6	77.1	76.9	77.1	77.4
Thickness (mm)	15.3	15.6	15.8	15.5	15.4
Moisture content (%)	7.3	7.9	7.4	7.5	7.3
Average moisture content (%)	7.5				

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Table 8: Water Tightness Test

Sample Reference	"BESTA" MgO board		
	1	2	3
Date of test	18/11/2008		
Dimension of cut specimens (mm)	610 x 508 x 16		
Height of clean water above prepared test specimens (mm)	50		
Observation	No sign of water droplet or dampness formed on the bottom surface of all test specimens was observed after 24hours.(See photographs 3, 4 & 5)		

Yip Poh Chuan
Testing Officer
Special Project Department

Tan Hong Choon
Asst. Manager
Special Project Department

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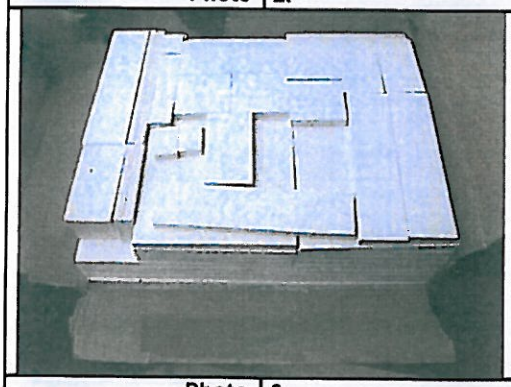
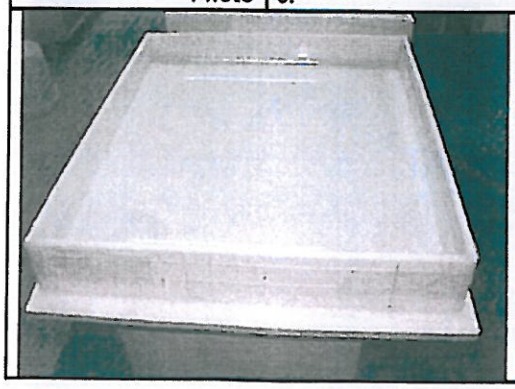
Photo 1.	
	One box of "BESTA" Magnesium Oxide (MgO) boards sample submitted by Best Rock Building Systems Pte Ltd on 03/11 /2008.
Photo 2.	
	"BESTA" Magnesium Oxide (MgO) boards of thickness 16mm, cut to the required size were received on 03/11/2008.
Photo 3.	
	Physical and Mechanical Properties - Water-tightness test in progress: MgO boards of 16mm thick cut specimens - 22 inch x 18 inch (559mm x 457mm). Water height of 2 in (50mm) maintained above the top surfaces at 23 ± 2°C and 50 ± 5% relative humidity for the 24 hours test.

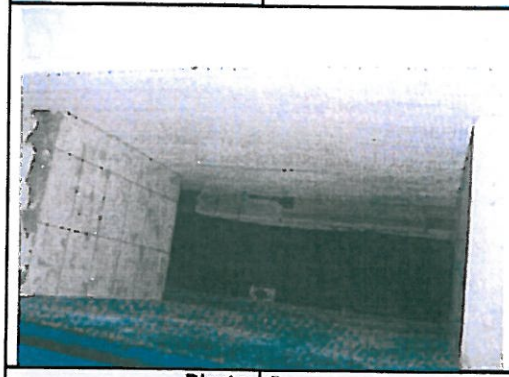
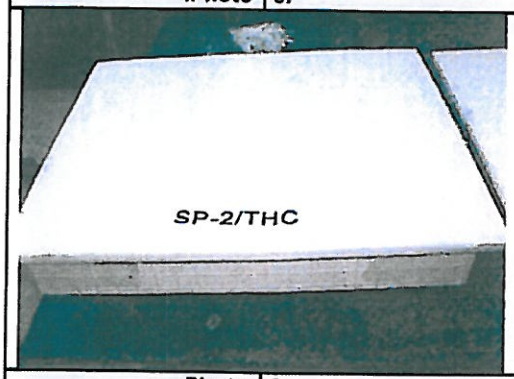
Photo 4.	
	Physical and Mechanical Properties - Water-tightness test. Test in progress: After 24 hours, no sign of water droplet or dampness on the underside of test specimens was observed.
.Photo 5.	
	Physical and Mechanical Properties in the lab for water tightness test. Photo shows the underside of the specimens No apparent defect was observed of all the three test specimens at the conclusion of water-tightness test after 24 hours.
Photo 6.	
	Physical and Mechanical Properties – Moisture Movement test. Cut test specimens of 305 x 76mm x 16mm MgO board.

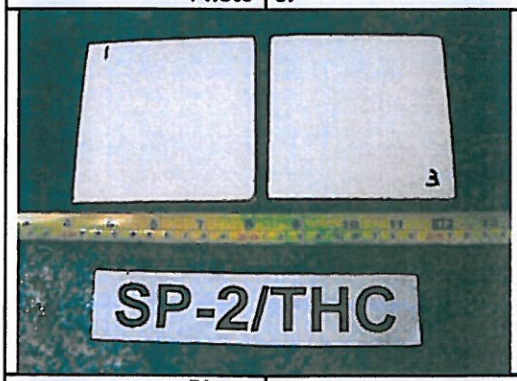
Photo 7.	
	Physical and Mechanical Properties – Moisture Content test. Cut test specimens of 152 x 76mm x 16mm MgO board.
Photo 8.	
	Physical and Mechanical Properties – Water Absorption test. Cut test specimens of 100 x 100 x 16mm MgO board.
Photo 9.	
	Physical and Mechanical Properties – Density. Cut test specimens of 60 x 40mm x 16mm MgO.

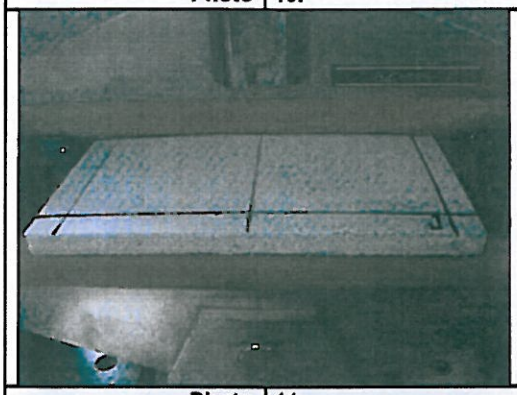
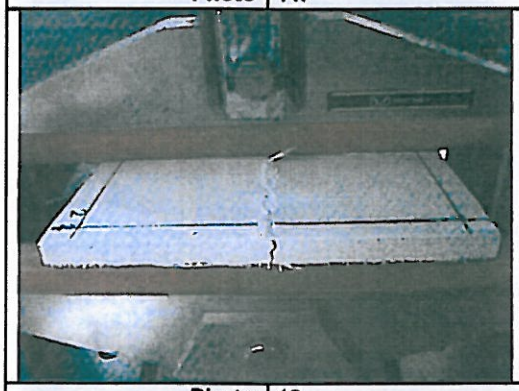
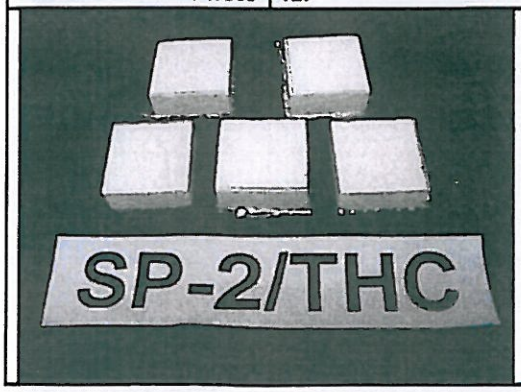
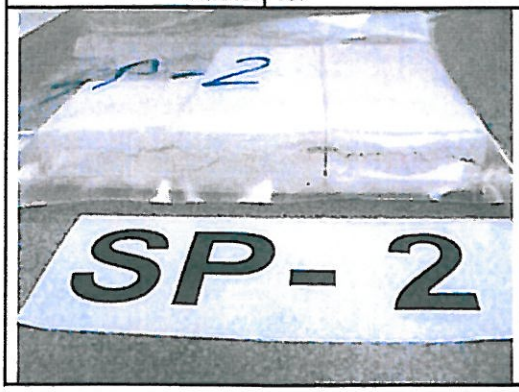
Photo 10.	
	Physical and Mechanical Properties – Bending Strength test. Photo shows the cut test specimen after conditioning and subjected to bending load supported at a span of 215mm.
Photo 11.	
	Physical and Mechanical Properties – Bending Strength test. After 1st break, the fractured test specimens were assembled for a second bending test along an axis perpendicular to that used in the 1st test.
Photo 12.	
	Physical and Mechanical Properties – Linear Thermal shrinkage test. Cut test specimens of 35 x 35mm x 16mm MgO.

Photo 13.	
	Physical and Mechanical Properties – Linear Thermal shrinkage test . Photo shows cracks on the tested specimens of 35 x 35mm x 16mm MgO after 4 hours in furnace at 950 °C.

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Singapore 608925
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Website: www.setsco.com

TEST REPORT

(This Report is issued subject to the terms & conditions set out below)

Your Ref: - Quotation SPD/ thc2008/ dw003R dd 17th April 2008
Our Ref: SP- 2 (10) /THC

Date: 19/09/2008

Subject : Determination of Physical and Mechanical Properties of "BESTA" Mangnesium Oxide (MgO) board, submitted by Best Rock Building Systems Pte Ltd on 11/07 /2008.

Tested For : **M/s Best Rock Building Systems PTE LTD**
14 Zion Road
Singapore 247732
Attn: Mr. Daniel Wong

Method of Test : **Physical and Mechanical Properties :**
1) Density : ISO TR 1896 : 1991 - clause 6.3
2) Bending Strength (Dry and Saturated) : ISO TR 1896 : 1991 - clause 6.4
3) Linear Thermal Shrinkage (drying shrinkage) : ISO TR 1896 : 1991 - clause 6.7
4) Moisture Movement Test : ASTM C 1185 - Clause 8
5) Moisture Content : ASTM C 1185 - clause 10
6) Water Absorption: ASTM C 1185 - clause 9
7) Water Tightness Test : ASTM C 1185 - clause 11

Specification adopted : ISO TR 1896 : 1991 Technical Report : Products in Fibre-reinforced Cement - Non-combustible Fibre-reinforced boards of Calcium Silicate or cement for Insulation and Fire Protection.

Description of Sample : "BESTA" Magnesium Oxide (MgO) boards of thickness 10mm, cut to the required size were received (See photos attached).

Test Results : Table 1: Test Summary
Table 2 to 8 - Individual Test Result.

Terms & conditions:
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Job No: SP -2 (10) /THC

Results:

Table 1 : Summary of Test Results on Physical and Meachanical Properties to ISO TR 1896 : 1991 / ASTM C1185

(Test Results on Material Property are attached)

S/N	Type of Test	Clause, Methods	Sample Sizes	Besta MgO Board (10 mm thick)
1	Density	Cl.6.3, ISO TR 1896	60 x 40 x 10 mm	1060 Kg /m³
2	Bending Strength (Dry and saturated)	Cl.6.4, ISO TR 1896	250 x 250 x 10 mm	5.1 N/mm² (Dry); 6.2 N/mm² (Saturated)
3	Linear Thermal Shrinkage	Cl.6.7, ISO TR 1896	35 x 35 x 10 mm	Samples softened & crumpled after subjected to 950°C for 4 hours
4	Moisture Movement	Cl.8, ASTM C 1185	305 x 76 x 10 mm	0.076%
5	Water Absorption	Cl.9, ASTM C 1185	100 x 100 x 10 mm	22.0%
6	Moisture Content	Cl.10, ASTM C 1185	152 x 76 x 10 mm	9.6%
7	Water Tightness	Cl.11, ASTM C 1185	610 x 508 x 10 mm	Dampness appeared after 5 hours

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Results:

Table 2: Density Test

Sample Reference	"BESTA" MgO board (10mm thick)				
	1	2	3	4	5
Date of test	18/07/2008				
Dimension of cut specimen (mm)	60 x 40 x 10mm				
Measured length (mm)	60.2	60.4	60.1	59.7	60.7
Measured width (mm)	37.9	38.7	39.9	38.8	38.2
Measured thickness (mm)	10.2	10.2	10.3	10.2	10.1
Net dry density (kg/m^3)	1050	1070	1050	1070	1070
Mean net dry density (kg/m^3)	1060				

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Results:

Table 3: Bending Strength (Dry and Saturated) Test

Sample Reference	"BESTA" MgO board (10mm thick)							
	Dry strength				Saturated strength			
	1	2	3	4	5	6	7	8
Date of Test	05/08/08							
Dimension of cut specimen (mm)	250 x 250 x 10 mm (thick)							
Distance bewteen supports (mm)	215							
Measured length (mm)	256.7	249.3	248.4	248.6	250.2	250.4	249.6	246.7
Measured width (mm)	251.0	249.0	247.8	246.1	249.5	248.7	250.0	246.9
Thickness measured along the line of fracture - 1st break (mm)	10.1	10.2	10.3	10.2	10.3	10.2	10.3	10.2
Thickness measured along the line of fracture - 2nd break (mm)	10.2	10.2	10.1	10.0	10.3	10.2	10.2	10.1
Mass of specimen after oven dried (g)	496.1	473.9	450.0	475.7	701.2	458.3	704.6	442.2
Mass of specimen after immersed in water for 24 hrs pior to test - Oven Dry (g)	-	-	-	-	829.5	587.9	837.0	576.2
Date of Test	11/08/08				12/08/08			
Breaking load -1st break (N)	377	432	354	438	682	481	436	459
Breaking load - 2nd break (N)	492	374	414	351	429	455	654	379
Bending strength - 1st break (N/mm^2)	4.8	5.4	4.4	5.5	8.4	6.0	5.4	5.8
Bending strength - 2nd break (N/mm^2)	6.0	4.7	5.2	4.6	5.2	5.7	8.0	4.8
Mean bending strength (N/mm^2)	5.1				6.2			

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Results:

Table 4: Linear Thermal Shrinkage Test

Samples Reference	"BESTA" MgO board (10mm thick)				
	1	2	3	4	5
Dimension of cut specimens (mm)	35 x 35 x 10mm				
Date of Test	07/08/08				
Temperature of furnace for 4 hours at test	950 °C				
Remarks	All specimens softened and crumpled when pressed lightly with fingers after the test				

Results:

Table 5: Moisture Movement (Linear Change) Test

Sample Reference	"BESTA" MgO board (10mm thick)			
	1	2	3	4
Date of Test	06/08/08			
Dimension of cut specimens (mm)	305 x 76 x 10 mm			
Length (mm)	304.7	304.7	304.9	304.9
Width (mm)	76.8	75.9	75.6	76.7
Thickness (mm)	10.2	10.6	10.3	10.4
Measurement of specimen after condition at R.H 30%	14.568	14.353	14.750	14.366
Measurement of specimen after condition at R.H 90%	14.579	14.365	14.760	14.377
Linear change %	0.076	0.084	0.068	0.077
Average Linear Change %	0.076			

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Results:

Table 6: Moisture Content Test

Sample Reference	"BESTA" MgO board (10mm thick)				
	1	2	3	4	5
Date of Test	5/8/2008				
Dimension of cut specimens	152 x 76 x 10				
Length (mm)	151.6	151.6	150.2	150.4	151.7
Width (mm)	75.9	75.0	75.8	75.3	76.6
Thickness (mm)	10.06	10.33	10.38	10.09	10.23
Moisture content (%)	10.5	9.5	9.0	10.0	9.0
Average moisture content (%)	9.6				

Results:

Table 7: Water Absorption Test

Sample Reference	"BESTA" MgO board (10mm thick)									
	1	2	3	4	5	6	7	8	9	10
Date of test	25/07/2008									
Dimension of cut specimens (mm)	100 x 100 x 10									
Length (mm)	100.6	100.8	97.9	100.5	99.6	101.0	99.5	99.6	100.7	100.3
Width (mm)	99.2	99.9	98.7	99.7	99.1	99.9	99.4	99.3	97.8	96.1
Water absorption by mass (%)	23.0	23.0	21.0	23.0	21.5	23.5	20.0	21.0	21.5	23.0
Average water absorption by mass (%)	22.0									

Job No: SP - 2 (10) / THC
Results:

Table 8: Water Tightness Test

Sample Reference	"BESTA" MgO board		
	1	2	3
Date of test	11/08/08		
Dimension of cut specimens (mm)	610 x 508 x 10		
Height of clean water above prepared test specimens (mm)	50		
Observation	Dampness on the bottom surface observed (Refer to photographs 2 & 3)		

Yip Poh Chuan
Testing Officer
Special Project Department

Tan Hong Choon
Asst. Manager
Special Project Department

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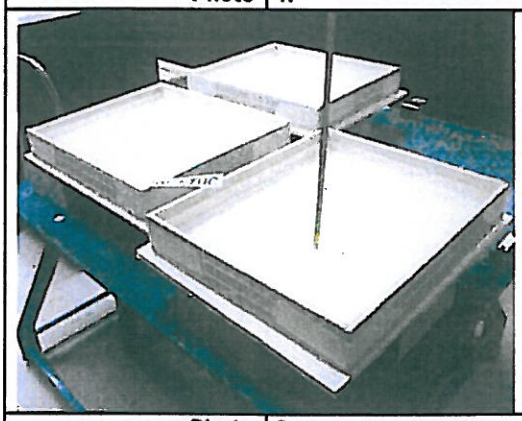
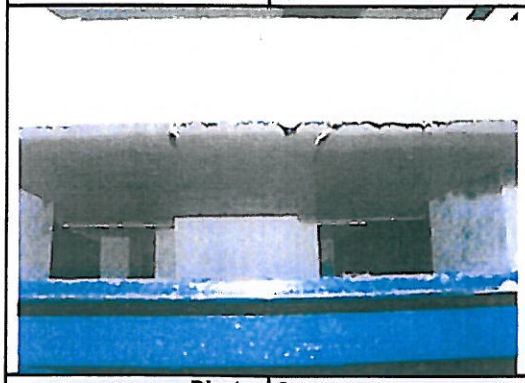
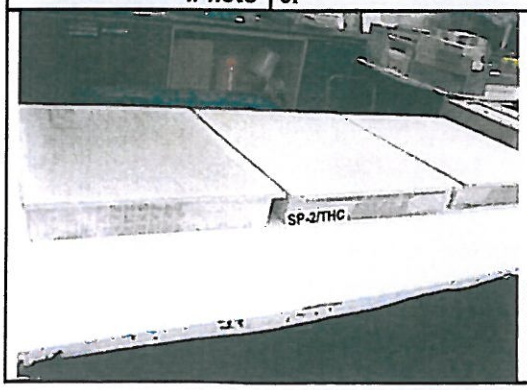
Photo 1.	
	Physical and Mechanical Properties - Water-tightness test. Test in progress : MgO boards of 10mm thick cut into test specimens of dimension 22 inch x 18 inch (559mm x 457mm) with Water height of 2 in (50mm) been maintained above the top surfaces at 23 ± 2°C and 50 ± 5% relative humidity for the 24 hours test.
Photo 2.	
	Physical and Mechanical Properties - Water-tightness test. Test in progress: After about 5 hours, sign of water dampness started to appear on the underside of test specimens.
.Photo 3.	
	Physical and Mechanical Properties in the lab for water tightness test. Photo shows the appearance of dampness on the underside of all the three (03) test specimens at the conclusion of water-tightness test after 24 hours.

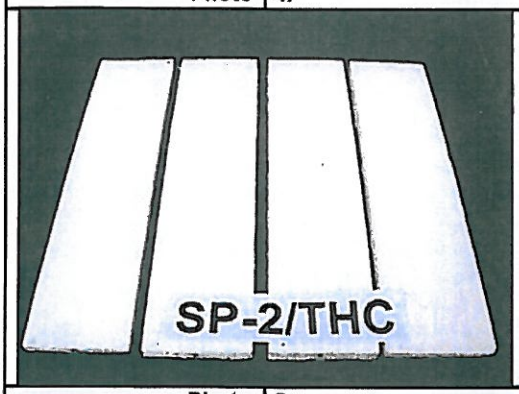
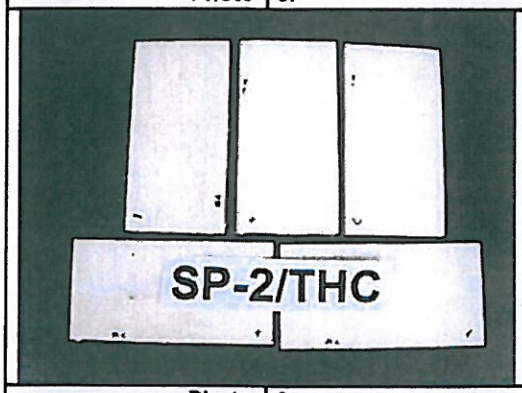
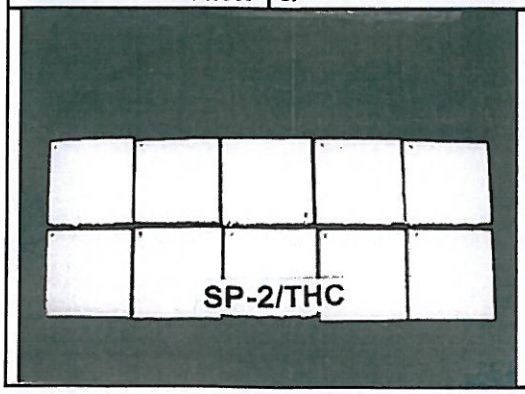
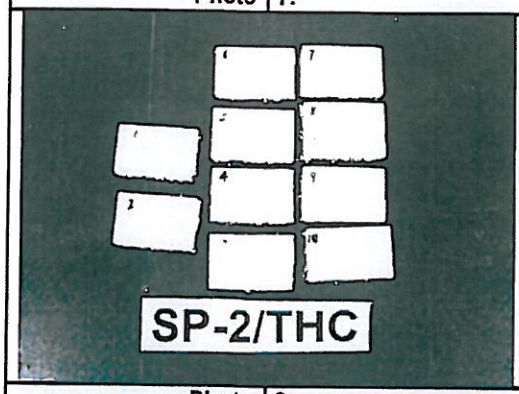
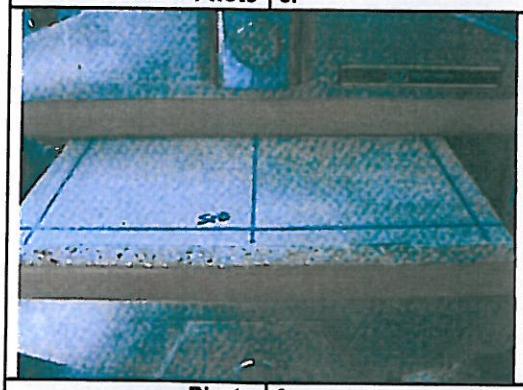
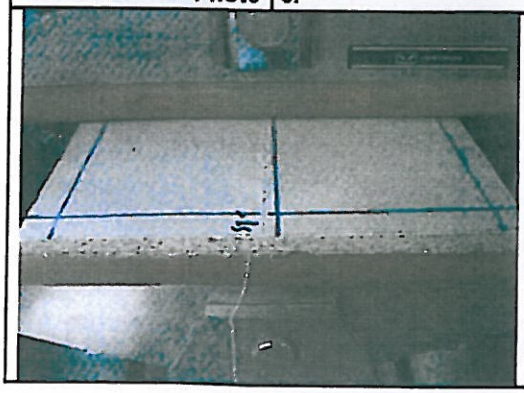
Photo 4.	
	Physical and Mechanical Properties – Moisture Movement test. Cut test specimens of 305 x 76mm x 10mm MgO board.
Photo 5.	
	Physical and Mechanical Properties – Moisture Content test. Cut test specimens of 152 x 76mm x 10mm MgO board.
Photo 6.	
	Physical and Mechanical Properties – Water Absorption test. Cut test specimens of 100 x 100 x 10mm MgO board.

Photo 7.	
	Physical and Mechanical Properties – Density. Cut test specimens of 60 x 40mm x 10mm MgO.
Photo 8.	
	Physical and Mechanical Properties – Bending Strength test. Photo shows the cut test specimens after conditioning and subjected to bending load supported at a span of 215mm.
Photo 9.	
	Physical and Mechanical Properties – Bending Strength test. After 1st break, the fractured test specimens were assembled for a second bending test along an axis perpendicular to that used in the 1st test.

b) Fire Resistance Test Report

b1) Fire Resistance Test On A Non Load Bearing Besta Wall Panel

Test Report No. S08MEC05565/IHN
dated 26 Sep 2008

PSB Singapore

Note: This report is issued subject to TÜV SÜD PSB's "Terms and Conditions Governing Technical Services" The terms and conditions governing the issue of this report are set out as attached within this report.

Choose certainty.
Add value.

SUBJECT:

Fire resistance test on a non load-bearing BESTA Wall panel submitted by Best Rock Building Systems Pte Ltd.

TESTED FOR:

Best Rock Building Systems Pte Ltd
14 Zion Road
Singapore 247732

Attn: Mr. Daniel Wong

DATE SUBMITTED:

10 Sep 2008

DATE OF TEST:

15 Sep 2008

PURPOSE OF TEST:

1 To determine the fire resistance of the specimen when tested in accordance with BS 476 Part 22: 1987 "Methods for Determination of the Fire Resistance of Non-loadbearing Elements of Construction - Determination of the Fire Resistance of Partition."

PSB TEST
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LA-2007-0380-A
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LA-2007-0381-F
LA-2007-0382-B
LA-2007-0383-G
LA-2007-0384-G
LA-2007-0385-E
LA-2007-0386-C
The results reported herein have been performed in accordance with the laboratory's terms of accreditation under the Singapore Accreditation Council - Singapore Laboratory Accreditation Scheme. Tests/Calibrations marked "Not SAC-SINGLAS Accredited" in this Report are not included in the SAC-SINGLAS Accreditation Schedule for our laboratory.

Laboratory:
TÜV SÜD PSB Pte. Ltd.
Testing Services
No 1 Science Park Drive
Singapore 118221

Phone : +65-6885 1333
Fax : +65-6776 8670
E-mail: testing@tuv-sud-psb.sg
www.tuv-sud-psb.sg
Co Reg : 199002667R

Regional Head Office:
TÜV SÜD Asia Pacific Pte. Ltd.
3 Science Park Drive, #04-01/05
The Franklin, Singapore 118223
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TEST PROCEDURE:

2 Before the commencement of test, the ambient temperature in the general vicinity of the test specimen construction was ensured to be not exceeding 35°C. The datum values for each individual temperature and deflection measurements were also taken not more than 15 minutes before the commencement of test.

3 During the test, with commencement of heating of the specimen, the furnace temperature and pressure were controlled to comply with the requirements specified in BS 476: Part 20: 1987: clause 3.1 and 3.2 respectively. The pressure was controlled such that a linear pressure gradient of 8.5±2 Pa per 1000mm height exist above a neutral pressure axis at a height of approximately 1000mm above the notional floor level. However, the maximum pressure at the top of a vertical test construction shall not exceed 20Pa.

4 Throughout the heating period, the behaviour of the specimen was observed and monitored for compliance with the relevant performance criteria stated in clause 10 of BS 476: Part 20: 1987 (A summary is given in clause 9 of this report.) and the appropriate clause of BS 476: Part 22: 1987.

5 For insulated specimen, the mean temperature on the unexposed face were measured by five number of surface mounted thermocouples, with one placed approximately at the centre of each quadrant. In the presence of stiffener, through member or jointing, the thermocouples were located at least 50mm away.

6 For insulated specimen, the maximum temperature on the unexposed face were measured by thermocouples placed on locations on one vertical jointing and one at stiffeners which may be hotter than the average on the face. The thermocouples were placed at least 50mm away from edge of stiffeners or any jointing.

7 Observations, on the behaviour of the test specimen throughout the heating period, were made and recorded. As appropriate, cotton pads, gap gauges and roving thermocouple were used to establish the occurrence of failure.

8 The test was terminated when one or more failures as stated in the performance criteria occurred, or otherwise at a time agreed between the sponsor of test and the test laboratory.

PERFORMANCE CRITERIA:

9 The specimen is assessed against the following test criteria:

9.1 Loss of Integrity

Failure shall be deemed to have occurred when one of the following occurs:-

- When collapse or sustained flaming for more than 10 seconds on the unexposed face.
- When the cotton pad test is conducted, flames and/or hot gas causing flaming or glowing of the cotton pad.
- Where the cotton pad test cannot be conducted because of the level of radiation from the specimen, a through gap into furnace exceeding 6mm in width by 150mm in length exists or develops in the specimen.
- When a through gap into furnace exceeding 25mm diameter exists or develops in the specimen.

9.2 Insulation

Failure shall be deemed to have occurred when one of the following occurs:-

- If the mean unexposed face temperature increases by more than 140°C above its initial value.
- If the temperature recorded of at any position on the unexposed face is in excess of 180°C above the initial mean unexposed face temperature.
- When integrity failures occur.

DESCRIPTION OF TEST SPECIMEN:

10 The specimen consisted of a 3000mm (wide) x 3000mm (high) BESTA Wall panel of 112mm nominal thickness. The wall was constructed within a test frame with ordinary bricks of size 215mm x 90mm x 75mm laid along its base as lateral support and on two vertical sides of the wall. An overhead concrete lintel was constructed above the top perimeter of the panelled wall. A vertical expansion gap of approximately 25mm filled with ceramic was provided on one edge of the constructed wall. The test frame was mounted onto the furnace (PSB Asset No: 20009077) and fire resistance test was conducted at TÜV SÜD PSB Pte Ltd. laboratory located at No. 10 Tuas Avenue 10, Singapore 639134.

11 Five pieces of BESTA Wall panels were vertically erected and interlocked with a tongue and groove jointing along the longitudinal edge. The nominal dimensions of each panel was 600mm (wide) x 3000mm (high) x 112mm (thick) and the average nominal weight of each panel was found to be 115.6kg. Core material of each panel was said to be "Perlite" and encased within BESTA fire resistance boards of 12mm thick with 88mm x 25mm and 88mm x 18mm thick edge lips on each end.

12 Along the tongue and groove vertical joints connecting each panel, "Bostik Fireban One" fire rated polyutherane sealant was applied. All exposed gaps between panels and edge perimeter of wall were grouted with "Hilti CP606" fire resistance acoustic mastic sealant. Steel angle 37mm x 37mm x 2.3mm thick were placed along the base and top edge on both sides of the constructed wall. The steel angles were fastened to lintel and wall floor with anchor bolts at maximum distance of 1150mm apart.

13 An inspection on the specimen was conducted during the construction stages by a TÜV SÜD PSB staff to verify on its material used, dimensions and designs. Details of the partition wall are as shown in Figure 2 to 5.

14 Installation of the test specimen onto the test furnace was arranged and carried out by Best Rock Building Systems Pte Ltd.

TEST RESULTS:

15 Table 1 shows the temperature rise for the furnace and the standard curve. In addition, the table shows the percentage difference between the area under the standard curve and the area under the furnace curve compared with the percentage tolerance allowable within the standards.

16 Table 2 and 3 show the mean and maximum unexposed face temperature above the initial temperature.

17 Table 4 shows the deflection measurement of the wall towards the furnace along its mid-height.

18 Figure 1 shows the actual time-temperature curve of furnace in relation to the specified time-temperature curve.

19 Photographs of the test are shown in Plates 1 to 6.

20 Observations were made during the test on the unexposed face of the test specimen and these are given in Appendix 1 of this report.

21 The results only relate to the behaviour of the specimen of the element of construction under the particular conditions of the test. They are not intended to be the sole criteria for assessing the potential fire performance of the element in use nor do they reflect the actual behaviour in fires.

CONCLUSION:

22 The specimen satisfied the requirements of the BS 476: Part 22: 1987 for the periods stated below:

Integrity	:	199 minutes
Insulation	:	164 minutes

REMARKS:

23 Integrity

At 200 minutes of heating, a 6mm gap gauge was employed at through gap between panel C and D and was able to traverse vertically for 200mm. Therefore, the integrity of the BESTA Wall meets the standard for 199 minutes.

24 Insulation

At 165 minutes of test, the maximum mean temperature rise and maximum temperature rise above initial temperature on the unexposed face of specimen were 95.3°C and 190.2°C respectively. Therefore, the insulation of the BESTA Wall meets the standard for 164 minutes.

WITNESSES

25 The test was witnessed by the following representative:

Best Rock Building Systems Pte Ltd : Mr. Daniel Wong

Ismail Bin Hassan
Associate Engineer

Chan Lung Toa
Product Manager
(Fire Safety & Security Products)
Mechanical

PSB Singapore

Table 1: Comparison of area under the curve

Time (min)	Temperature rise (°C)		Area under curve (°C min)		Percentage difference (%)	Standard tolerance ±%
	Standard	Furnace	Standard	Furnace		
5.0	556.4	547.8	2038.1	1920.6	-5.8	
10.0	658.4	661.5	5102.7	4935.5	-3.3	15.0
15.0	718.6	684.3	8554.8	8237.9	-3.7	
30.0	821.8	824.3	20195.3	19805.4	-1.9	10.0
60.0	925.3	929.3	46579.6	46353.1	-0.5	
120.0	1029.0	1033.9	105566.9	105579.6	0.0	
200.0	1105.5	1109.1	191208.2	191440.9	0.1	5.0

Table 2: Unexposed face temperature of the BESTA Wall

Time (min)	Thermocouple no.					Mean Temp (°C)	Above initial mean temp (°C)	
	100	101	102	104	105		Mean temp	Max. temp
0.0	27.4	27.8	27.6	28.1	27.8	27.7	-	-
30.0	28.8	30.3	35.8	35.4	67.3	39.5	11.8	39.6
60.0	45.1	46.8	52.0	50.2	58.8	50.6	22.8	31.0
90.0	63.2	63.4	80.5	66.9	77.3	70.3	42.5	52.8
120.0	77.1	80.4	89.5	81.9	84.0	82.6	54.8	61.7
150.0	99.3	87.0	112.7	85.4	88.8	94.6	66.9	84.9
164.0	113.7	98.6	196.5	86.4	96.2	118.3	90.5	168.7
165.0	114.4	99.6	**217.9**	86.6	96.9	123.1	95.3	190.2

Note: The mean temperatures were derived from thermocouple points 100 to 102 and 104 to 105.

Table 3: Additional unexposed face temperature of the BESTA Wall

Time (min)	Thermocouple no.		Mean Temp (°C)	Max. temp above initial temp (°C)
	106	108		
0.0	27.7	27.8	27.7	-
30.0	31.1	77.2	54.1	49.4
60.0	53.3	82.6	67.9	54.9
90.0	71.6	85.3	78.4	57.5
120.0	80.3	86.9	83.6	59.1
150.0	91.0	89.4	90.2	63.2
164.0	108.3	89.4	98.8	80.5
165.0	109.0	89.1	99.1	81.2

Table 4 : Deflection of the BESTA Wall towards the furnace

Time (min.)	Measurement of deflection (mm)				
	A	B	C	D	E
10.0	6	6	6	6	2
20.0	6	9	10	8	4
30.0	7	10	10	8	4
45.0	8	11	11	8	4
60.0	8	11	11	8	4
90.0	7	8	10	6	2
120.0	6	8	10	5	2
150.0	5	8	10	5	2
180.0	7	8	0	10	5

Note: The measuring points at mid-height are indicated in Figure 2.

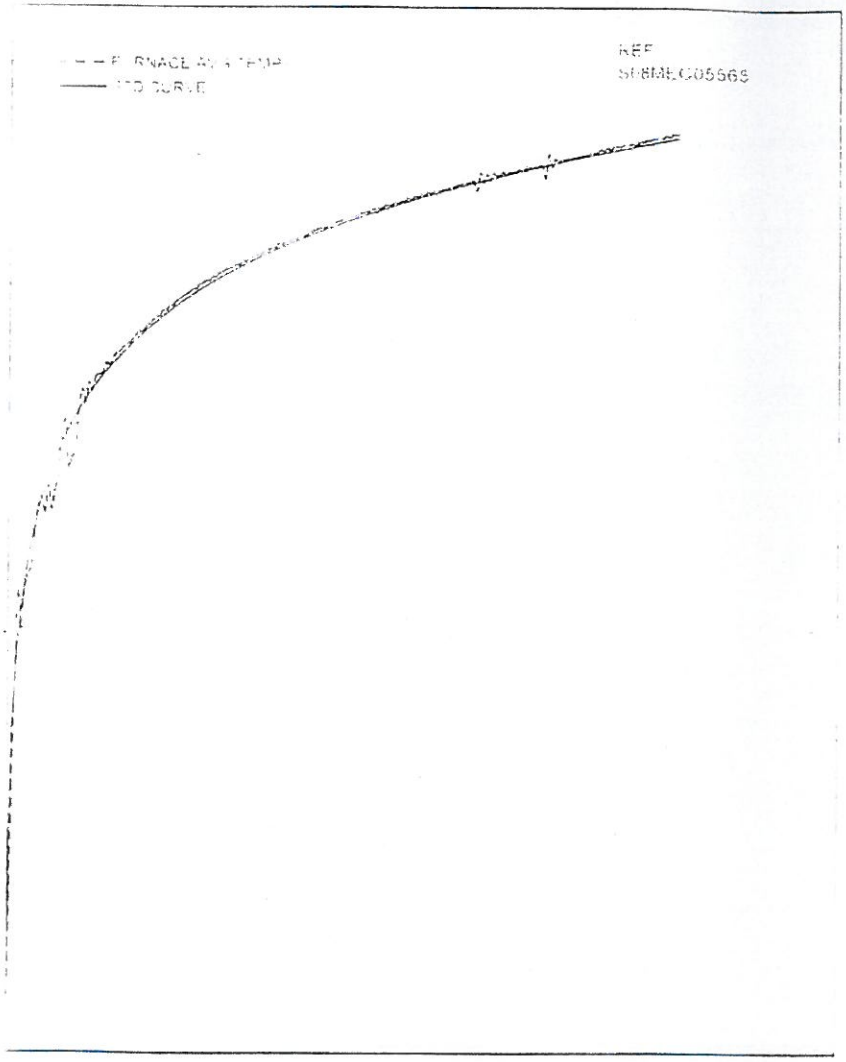

FIGURE 1 : FURNACE AVERAGE TEMPERATURE

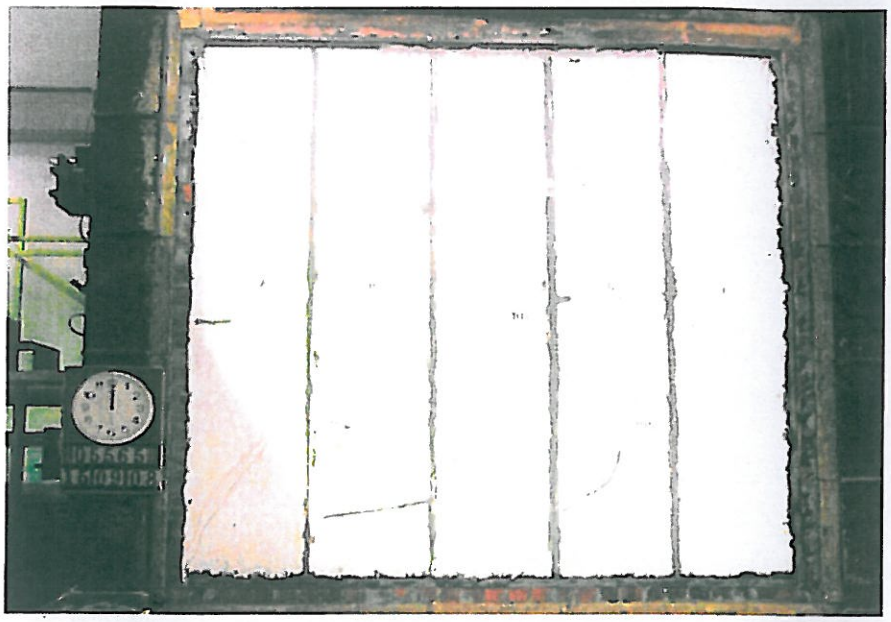

Plate 1: The unexposed face of specimen before test.

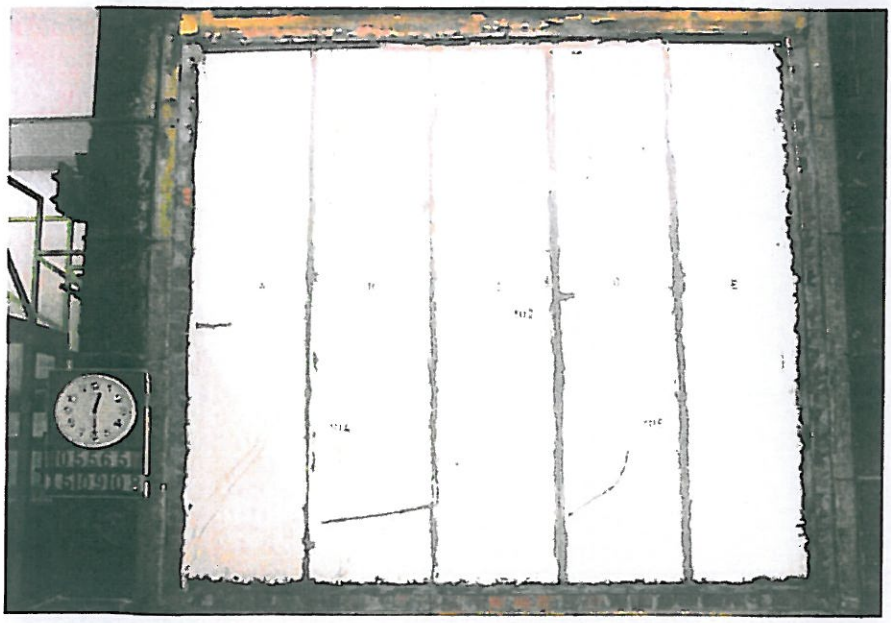

Plate 2: At about 30 minutes of test.

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Plate 3: At about 60 minutes of test.

Plate 4: At about 120 minutes of test.

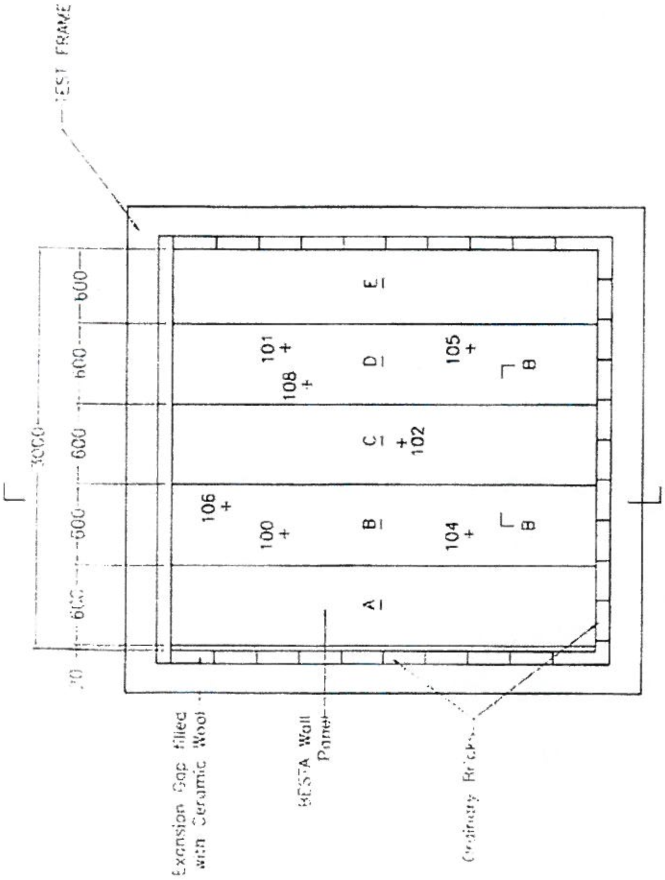
PSB Singapore

Plate 5: At about 200 minutes of test.

Plate 6: At about 204 minutes of test.

APPENDIX 1

Time (min:sec)	Observation on the unexposed face
00:00	Test commenced.
05:12	Intermittent audible 'boom' sound heard within the wall.
10:00	The wall partition began to deflect inward across its mid-height.
20:00	Increased inward deflections along its mid-height were measured.
30:00	Integrity of the wall observed to be intact.
60:00	No significance occurrence was observed. Integrity of wall remained intact.
90:00	No changes observed.
120:00	Integrity remained intact and no significance changes observed.
167:00	A bulging light grey patch began to emerge on wall surface below thermocouple point 102.
180:00	Grey patch mentioned at 167 minutes increased in area.
181:00	Delamination of wall panel skin along left edge of panel D at mid-height approximately 200mm long vertically.
185:00	A glow on panel C surface approximately 550mm below point 102 was observed.
190:00	Clearance between panel C and D adjacent to point 102 was observed to be radiating hot
200:00	A 6mm gap gauge employed at through gap between panel C and D and was able to traverse vertically for 200mm in length.
202:00	A single 'boom' sound heard. Continuous flaming for more than 10 seconds was observed at gap mentioned at 200 minutes.
204:00	Test was terminated.



'+' Indicates thermocouple points.

'_' Indicates deflection measurement points at mid-height.

FIGURE 2 : GENERAL ARRANGEMENT OF BESTA WALL ON THE UNEXPOSED SIDE

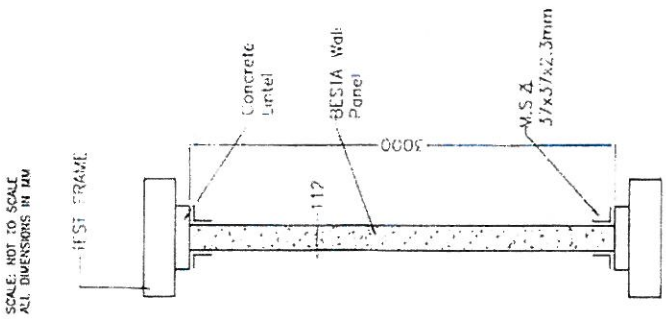


FIGURE 3 : SECTION A-A

PSB Singapore

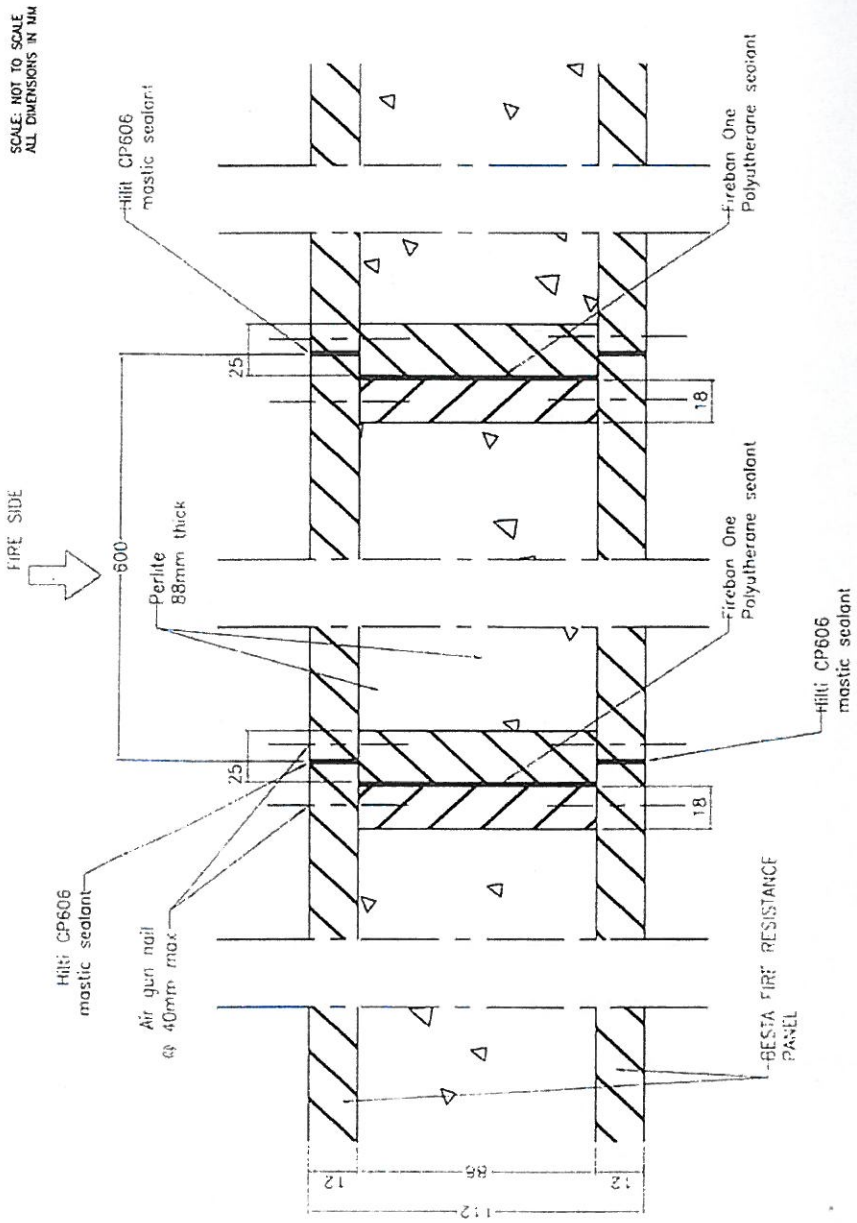


FIGURE 4 : SECTION B-B

PSB Singapore

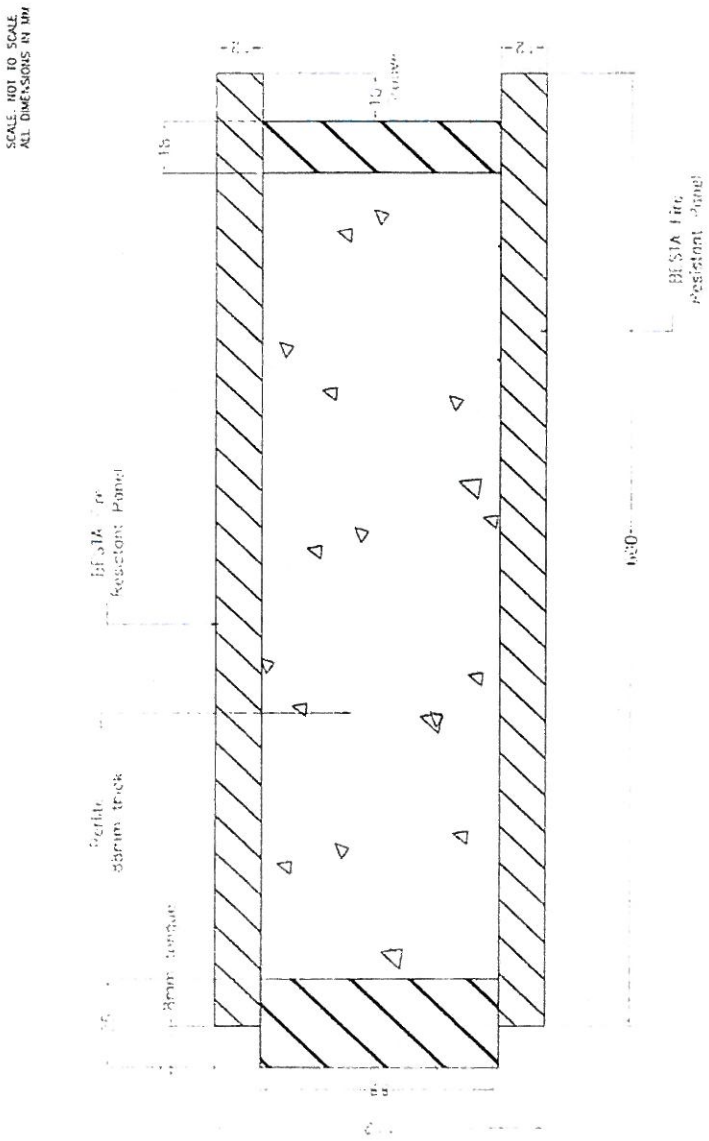


FIGURE 5 : BESTA FIRE RESISTANT PANEL DETAILS

This Report is issued under the following conditions:

1. Results of the testing/calibration in the form of a report will be issued immediately after the service has been completed or terminated.

2. Unless otherwise requested, a report shall contain only technical results. Analysis and interpretation of the results and professional opinion and recommendations expressed thereupon, if required, shall be clearly indicated and additional fee paid for, by the Client.

3. This report applies to the sample of the specific product/equipment given at the time of its testing/calibration. The results are not used to indicate or imply that they are applicable to other similar items. In addition, such results must not be used to indicate or imply that TÜV SÜD PSB approves, recommends or endorses the manufacturer, supplier or user of such product/equipment, or that TÜV SÜD PSB in any way "guarantees" the later performance of the product/equipment.

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9. This report shall not be reproduced wholly or in parts and no reference shall be made by the Client to TÜV SÜD PSB or to the report or results furnished by TÜV SÜD PSB in any advertisements or sales promotion.

10. Unless otherwise stated, the tests are carried out in TÜV SÜD PSB Pte Ltd, No.1 Science Park Drive Singapore 118221.

January 2008

Test Report No. 719178407-MEC10-MW
dated 22 Jun 2010

Note: This report is issued subject to TÜV SÜD PSB's "Terms and Conditions Governing Technical Services". The terms and conditions governing the issue of this report are set out as attached within this report.

PSB Singapore

Choose certainty.
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SUBJECT:

Fire resistance test on a non-loadbearing 75mm thick Besta Wall Panel drywall partition system submitted by Well & Able International Pte Ltd.

TESTED FOR:

Well & Able International Pte Ltd
103 Defu Lane 10
#02-03, BTH Building
Singapore 539223

Attn: Mr. Ronald Cheong

DATE SUBMITTED:

07 Jun 2010

DATE OF TEST:

14 Jun 2010

PURPOSE OF TEST:

1 To determine the fire resistance of the specimen when tested in accordance with BS 476: Part 22: 1987 "Methods for Determination of the Fire Resistance of Non-loadbearing Elements of Construction - Determination of the Fire Resistance of Partition."

TÜV SÜD PSB

ACCREDITED LABORATORY SAC-SINGLAS
LA-2007-0380-A
LA-2007-0380-A-1
LA-2007-0381-F
LA-2007-0382-B
LA-2007-0383-G
LA-2007-0384-G
LA-2007-0385-E
LA-2007-0386-C

The results reported herein have been performed in accordance with the laboratory's terms of accreditation under the Singapore Accreditation Council - Singapore Laboratory Accreditation Scheme. Tests/Calibrations marked "Not SAC-SINGLAS Accredited" in this Report are not included in the SAC-SINGLAS Accreditation Schedule for our laboratory.

Laboratory:
TÜV SÜD PSB Pte. Ltd.
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TÜV SÜD Asia Pacific Pte. Ltd.
3 Science Park Drive, #04-01/05
The Franklin, Singapore 118223

TEST PROCEDURE:

2 Before the commencement of test, the ambient temperature in the general vicinity of the test specimen construction was ensured to be not exceeding 35°C. The datum values for each individual temperature and deflection measurements were also taken not more than 15 minutes before the commencement of test.

3 During the test, with commencement of heating of the specimen, the furnace temperature and pressure were controlled to comply with the requirements specified in BS 476: Part 20: 1987: clause 3.1 and 3.2 respectively. The pressure was controlled such that a linear pressure gradient of 8.5±2 Pa per 1000mm height exist above a neutral pressure axis at a height of approximately 1000mm above the notional floor level. However, the maximum pressure at the top of a vertical test construction shall not exceed 20 Pa.

4 Throughout the heating period, the behaviour of the specimen was observed and monitored for compliance with the relevant performance criteria stated in clause 10 of BS 476: Part 20: 1987 (A summary is given in clause 9 of this report.) and the appropriate clause of BS 476: Part 22: 1987.

5 For insulated specimen, the mean temperature on the unexposed face were measured by five number of surface mounted thermocouples, with one placed approximately at the centre of each quadrant. In the presence of stiffener, through member or jointing, the thermocouples were located at least 50mm away.

6 For insulated specimen, the maximum temperature on the unexposed face were measured by thermocouples placed on locations on one vertical jointing and one at stiffeners which may be hotter than the average on the face. The thermocouples were placed at least 50mm away from edge of stiffeners or any jointing.

7 Observations, on the behaviour of the test specimen throughout the heating period, were made and recorded. As appropriate, cotton pads, gap gauges and roving thermocouple were used to establish the occurrence of failure.

8 The test was terminated when one or more failures as stated in the performance criteria occurred, or otherwise at a time agreed between the sponsor of test and the test laboratory.

PERFORMANCE CRITERIA:

9 The specimen is assessed against the following test criteria:

9.1 Loss of integrity

Failure shall be deemed to have occurred when one of the following occurs:-

When collapse or sustained flaming for more than 10 seconds on the unexposed face.

When the cotton pad test is conducted, flames and/or hot gas causing flaming or glowing of the cotton pad.

Where the cotton pad test cannot be conducted because of the level of radiation from the specimen, a through gap into furnace exceeding 6mm in width by 150mm in length exists or develops in the specimen.

When a through gap into furnace exceeding 25mm diameter exists or develops in the specimen.

9.2 Insulation

Failure shall be deemed to have occurred when one of the following occurs:-

If the mean unexposed face temperature increases by more than 140°C above its initial value.

If the temperature recorded of at any position on the unexposed face is in excess of 180°C above the initial mean unexposed face temperature.

When integrity failures occur.

DESCRIPTION OF TEST SPECIMEN:

10 The test assembly consisted of a non-loadbearing 3000mm (wide) x 3000mm (high) x 75mm thick drywall partition. The nominally 75mm thick partition was constructed vertically within a test frame with ordinary bricks bedded along the base as lateral support, along two vertical sides of the wall and a concrete lintel at top of wall. A free edge clearance of approximately 25mm wide filled with ceramic wool was provided along at one vertical side of the constructed partition. The test frame was mounted onto the furnace (PSB Asset No: 20009077). The fire resistance test was conducted at TÜV SÜD PSB's laboratory located at No. 10 Tuas Avenue 10, Singapore 639134.

The partition was constructed with 'Keel' steel 'U' channels of size 40mm x 50mm x 40mm x 0.6mm thick. The channels were secured onto the top/bottom and one vertical of the surrounding brickwall with 5.8mmØ x 38mm (L) self drilling screws spaced at 500mm apart except the free edge. 50mm thick 'SFF' rockwool of density found to be 37kg/m^3 was used to fill the voids between the channels and sandwiched by 12mm nominal thick Besta boards of density found to be 1015kg/m^3, secured with 3.5mmØ x 25mm(L) self drilling screws spaced at 400mm apart. Intermediate Besta board of size 200mm (wide) x 12mm nominal thick was placed along the butt jointing between boards, bonded with GX-Adhesive 282 on the 200mm wide surface and reinforced with screws along the butt joints at 400mm apart. Clearance between butt joints were filled with HC-119 Fire-retardant Silicone Sealant of 'HUA CHENG GUI' and finished with a layer of joint compound (mixture of GX-Cote 059w power and GX-Cote 059w liquid) laid over it, inclusive of screw locations.

11 An inspection on the drywall partition was conducted during the construction stages by a TÜV SÜD PSB officer to verify on its material used, dimensions and designs. Details of the wall panels construction are as shown in DWG NO.: W&A/WPS-500/T1-1 to W&A/WPS-500/T1-7 dated 14.06.10.

12 Installation of the test specimen onto the test furnace was arranged and carried out by Well & Able International Pte Ltd.

TEST RESULTS:

13 Table 1 shows the temperature rise for the furnace and the standard curve. In addition, the table shows the percentage difference between the area under the standard curve and the area under the furnace curve compared with the percentage tolerance allowable within the standards.

14 Figure 1 shows the actual time-temperature curve of furnace in relation to the specified time-temperature curve.

15 Table 2 and 3 show the mean and maximum unexposed face temperature above the initial temperature.

16 Table 4 shows the deflection measurement of the partition towards the furnace along its mid-height.

17 Photographs of the test are shown in Plates 1 to 6.

18 Observations were made during the test on the unexposed face of the test specimen and these are given in Appendix 1 of this report.

19 The results only relate to the behaviour of the specimen of the element of construction under the particular conditions of the test. They are not intended to be the sole criteria for assessing the potential fire performance of the element in use nor do they reflect the actual behaviour in fires.

CONCLUSION:

20 The specimen satisfied the requirements of the BS 476: Part 22: 1987 for the periods stated below:

Integrity	:	128 minutes
Insulation	:	97 minutes

REMARKS

21 Integrity

Integrity failures at 128 minutes 09 seconds of test where continuous flaming for more than 10 seconds at clearance between board butt joint about 150mm above mid height, 560mm from the fixed edge was seen. Therefore, the integrity of the drywall partition meets the standard for 128 minutes.

22 Insulation

At 97 minutes of test, the maximum mean temperature rise and maximum temperature rise above initial temperature on the unexposed face of specimen were 74.8°C and 177.1°C respectively. At 98 minutes of test, the maximum temperature rise above initial temperature was 182.1°C, which exceeded the maximum permissible temperature of 180°C. Therefore, the insulation of the drywall partition meets the standard for 97 minutes.

WITNESSES

23 The test was witnessed by the following representative:

Well & Able International Pte Ltd : Mr. Ronald Cheong

Mark Wong
Engineer

Chan Lung Toa
Product Manager
(Fire Safety & Security Products)
Mechanical Centre

Table 1 : Comparison of area under the curve

Time (min)	Temperature rise (°C)		Area under curve (°C min)		Percentage difference (%)	Standard tolerance ±%
	Standard	Furnace	Standard	Furnace		
5.0	556.4	577.2	2038.1	1925.0	-5.5	15.0
10.0	658.4	660.9	5102.7	4990.4	-2.2	
15.0	718.6	726.3	8554.8	8466.7	-1.0	10.0
30.0	821.8	821.5	20195.3	20110.6	-0.4	
35.0	844.8	841.2	24363.2	24281.5	-0.3	5.0
65.0	937.3	935.6	51236.6	51176.3	-0.1	
95.0	994.1	991.1	80261.0	80184.4	-0.1	
130.0	1041.0	1047.3	115918.0	115832.5	-0.1	

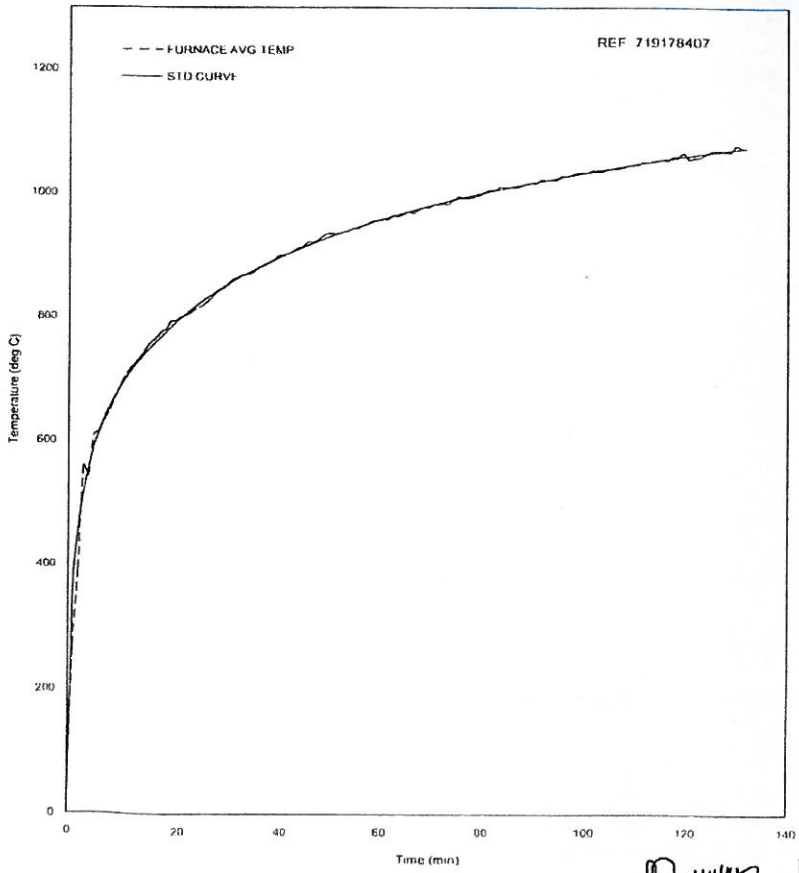

FIGURE 1 FURNACE AVERAGE TEMPERATURE

Table 2 : Unexposed face temperature on drywall partition system

Time (min)	Thermocouple no.					Mean Temp (°C)	Above initial mean temp (°C)	
	100	101	102	104	105		Mean temp	Max. temp
0.0	31.2	31.6	31.3	31.7	31.4	31.4	-	-
12.0	42.2	47.4	41.0	42.4	43.2	43.2	11.8	15.9
24.0	72.1	71.6	62.5	73.4	72.1	70.3	38.9	41.9
36.0	77.6	77.7	75.7	77.9	78.3	77.4	46.0	46.9
48.0	80.9	89.5	79.4	79.9	82.2	82.4	50.9	58.1
60.0	82.5	97.8	82.3	82.8	91.7	87.4	56.0	66.4
72.0	84.2	101.9	87.5	84.8	97.6	91.2	59.8	70.5
84.0	88.0	106.1	93.7	90.6	104.7	96.6	65.2	74.7
97.0	93.8	118.0	102.7	94.9	122.0	106.3	74.8	90.6
98.0	94.1	118.6	103.3	95.1	123.4	106.9	75.5	91.9
108.0	99.3	129.3	113.0	99.8	139.8	116.2	84.8	108.4
121.0	109.4	136.5	131.5	106.6	203.5	137.5	106.1	172.1
122.0	113.2	137.8	134.8	110.6	212.5	141.8	110.4	181.1
132.0	131.8	155.4	198.5	130.3	329.6	189.1	157.7	298.2

Table 3 : Additional unexposed face temperature on drywall partition system

Time (min)	Thermocouple no.		Mean temp (°C)	Above initial mean temp (°C)
	106	108		Max. temp
0.0	31.2	31.4	31.3	-
12.0	49.6	34.1	41.8	18.3
24.0	73.0	51.0	62.0	41.7
36.0	92.3	74.8	83.6	61.0
48.0	99.1	75.5	87.3	67.8
60.0	109.1	76.1	92.6	77.8
72.0	114.2	78.1	96.1	82.9
84.0	139.7	82.1	110.9	108.4
97.0	208.4	92.9	150.6	177.1
98.0	213.4	93.2	153.3	182.1
108.0	276.3	96.0	186.1	245.0
120.0	296.4	103.1	199.8	265.1
132.0	378.6	219.2	298.9	347.3

Table 4 : Deflection of the drywall partition system measure at mid height

Time (min.)	Measurement of deflection (mm)				
	A	B	C	D	E
10	9	12	12	13	10
20	20	22	24	23	17
30	41	53	57	54	36
45	63	85	90	80	60
60	68	89	97	81	63
90	53	65	70	57	47
120	63	78	73	70	55

Notes:

1) The deflection measuring points at mid-height are indicated in DWG NO.: W&A/WPS-500/T1-3.

2) A negative value indicates deflection away from the furnace.

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Photographs of test

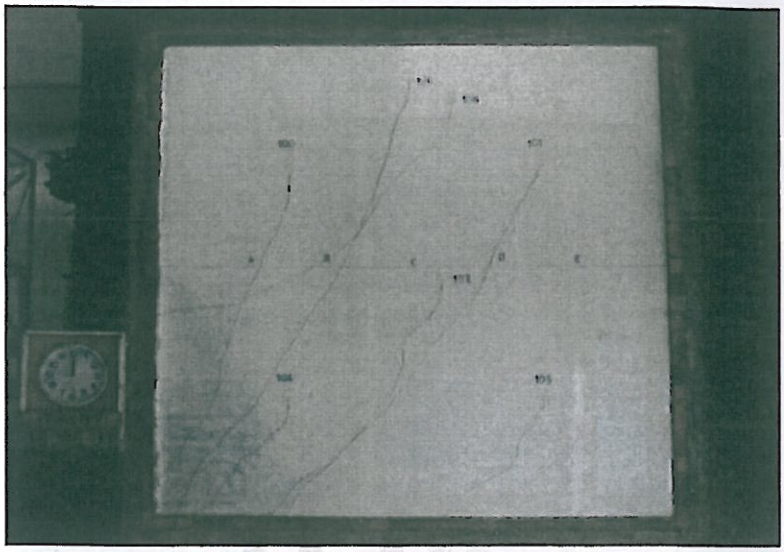

Plate 1 : The unexposed face of specimen before the test.

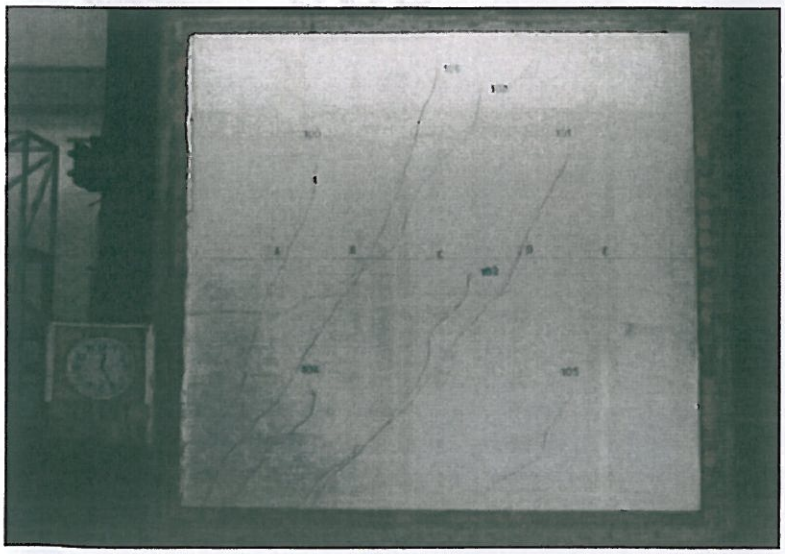

Plate 2 : At about 25 minutes of test.

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Photographs of test (cont'd)

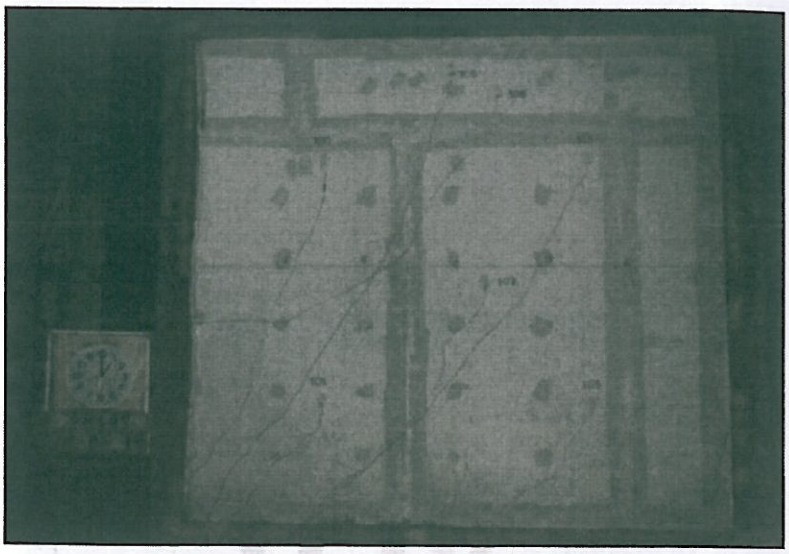


Plate 3 : At about 60 minutes of test.

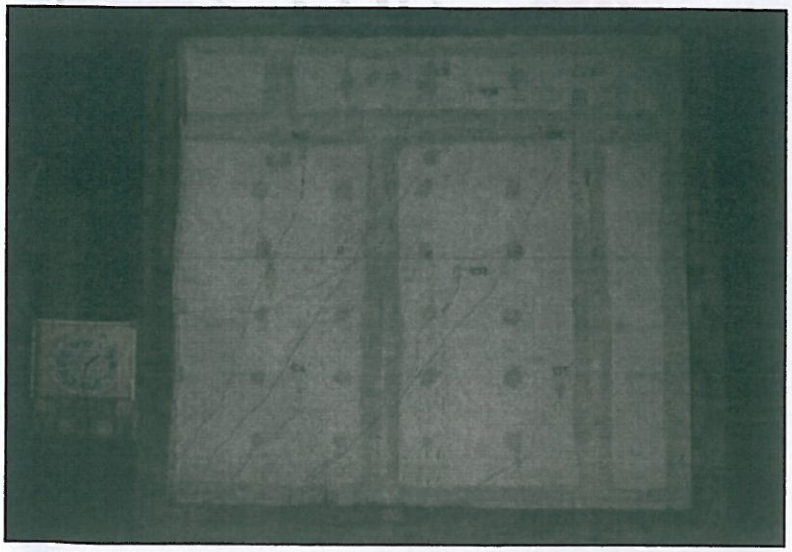


Plate 4 : At about 91 minutes of test

Photographs of test (cont'd)

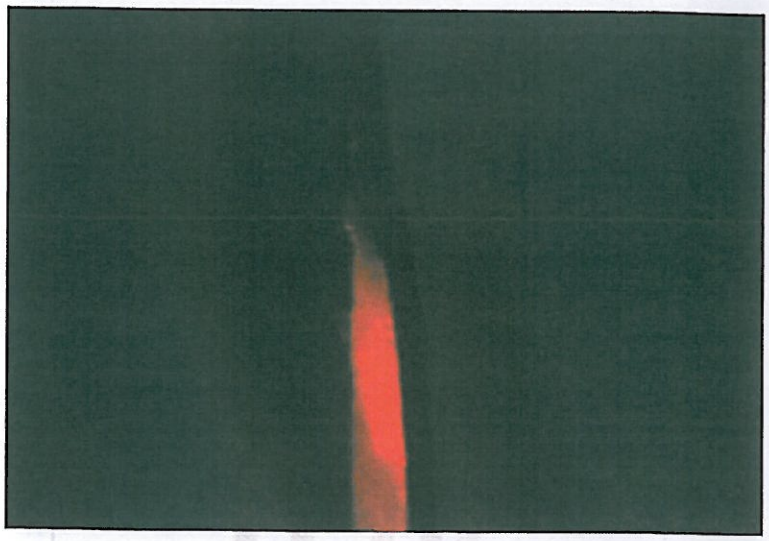


Plate 5 : At about 128 minutes 09 seconds of test, Continuous flaming for more than 10 seconds from the clearance developed from the crackline about 560mm from fixed edge, 200mm above mid height was seen.

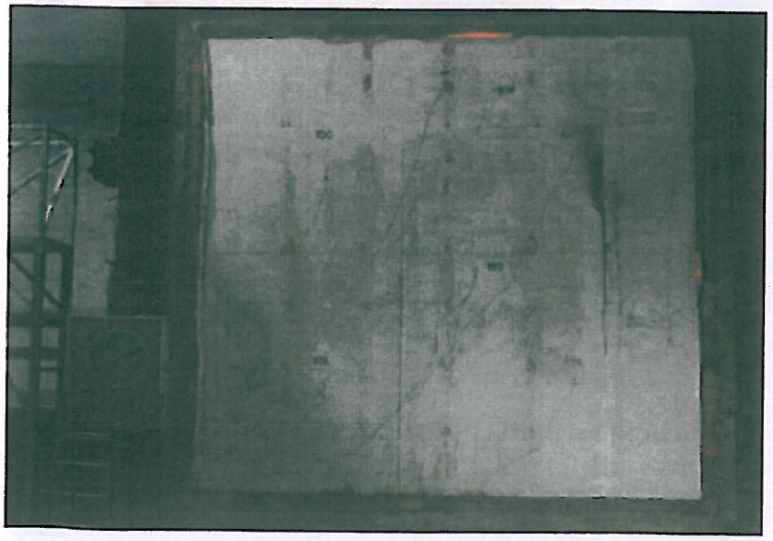
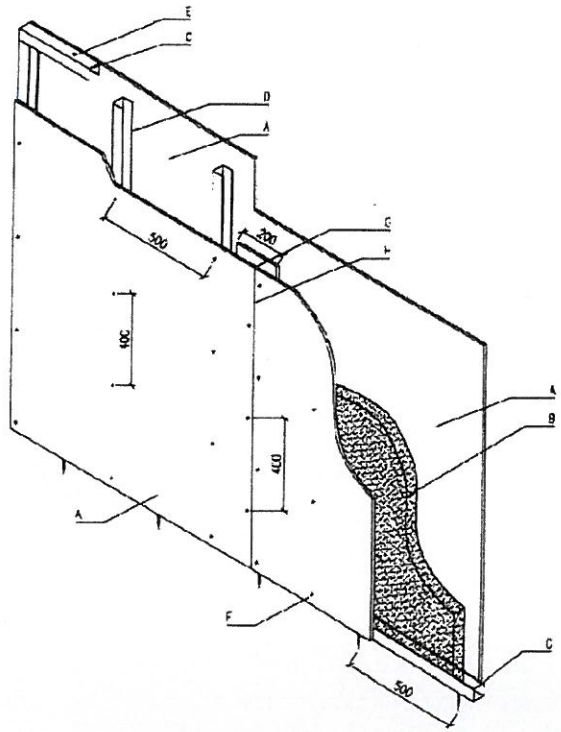


Plate 6 : At about 132 minutes of test.

APPENDIX 1

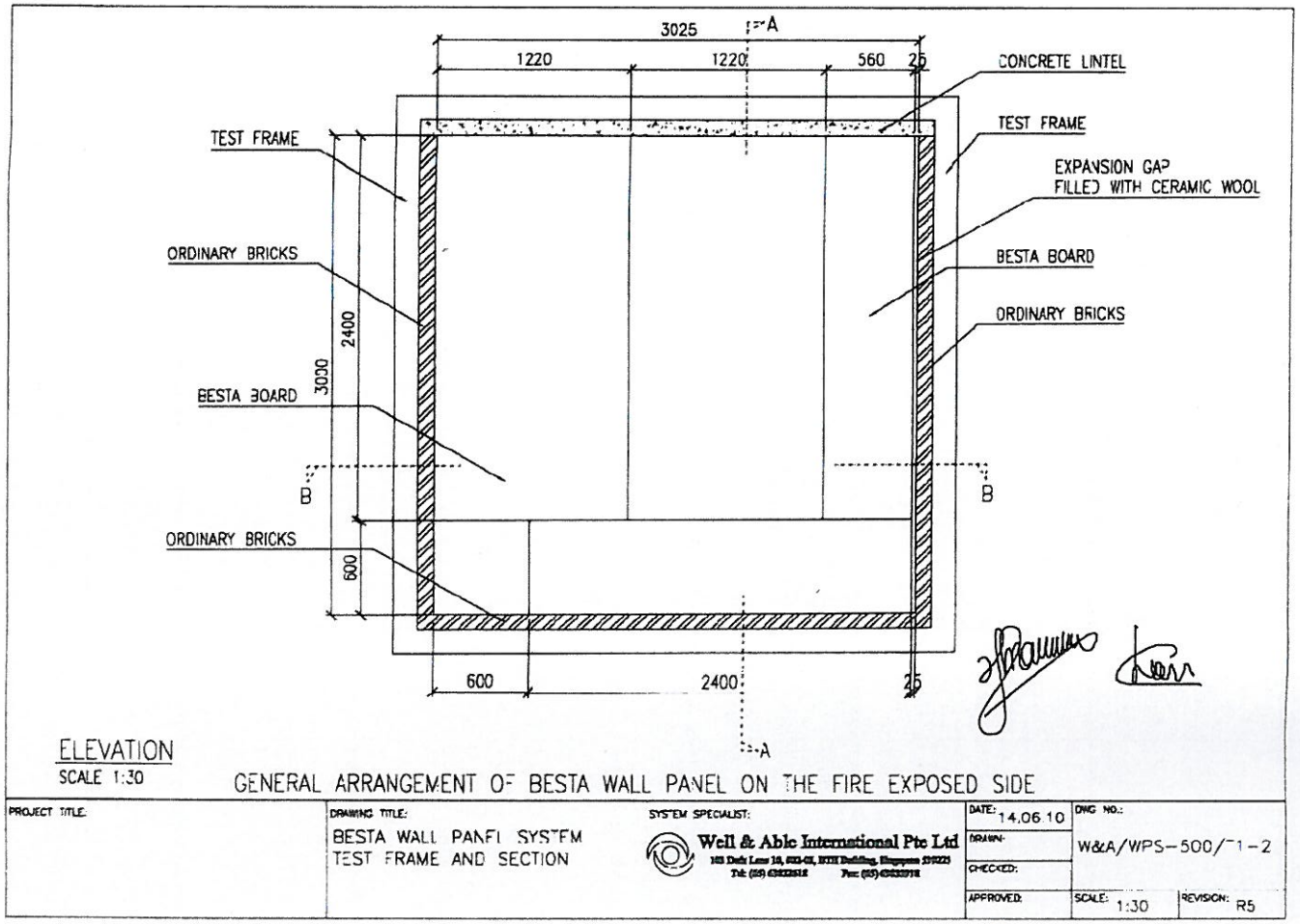
Time (min:sec)	Observations on the unexposed face
00:00	Test commenced.
15:00	No significant changes.
30:00	A vertical crackline about 1220mm from free edge was seen.
40:00	Smoke emission was seen from all edges except free edge.
45:00	A vertical crackline was seen about 560mm from fixed edge at around mid height.
60:00	Smoke can be seen emitting from crackline mentioned at 30 minutes.
75:00	Smoke can be seen emitting from crackline mentioned at 45 minutes. Several black spots can be seen along the bottom edge. Glowing at mid height on the fixed edge was seen.
105:00	Discolouration along the crackline about 560mm from fixed edge, 200mm above mid height was seen. Horizontal crackline about 600mm from top edge was seen.
120:00	Crackline mentioned at 105 minutes developed into clearance of about 10mm with glowing. But not a through gap.
123:00	Clearance mentioned at 120 minutes increased to about 20mm with glowing.
128:09	Continuous flaming for more than 10 seconds from the clearance mentioned at 120 minutes was seen, **Integrity failure occurred.**
132:00	Test was terminated upon requested by the sponsor of test. Flaming mentioned at 128 minutes 09 seconds continued.

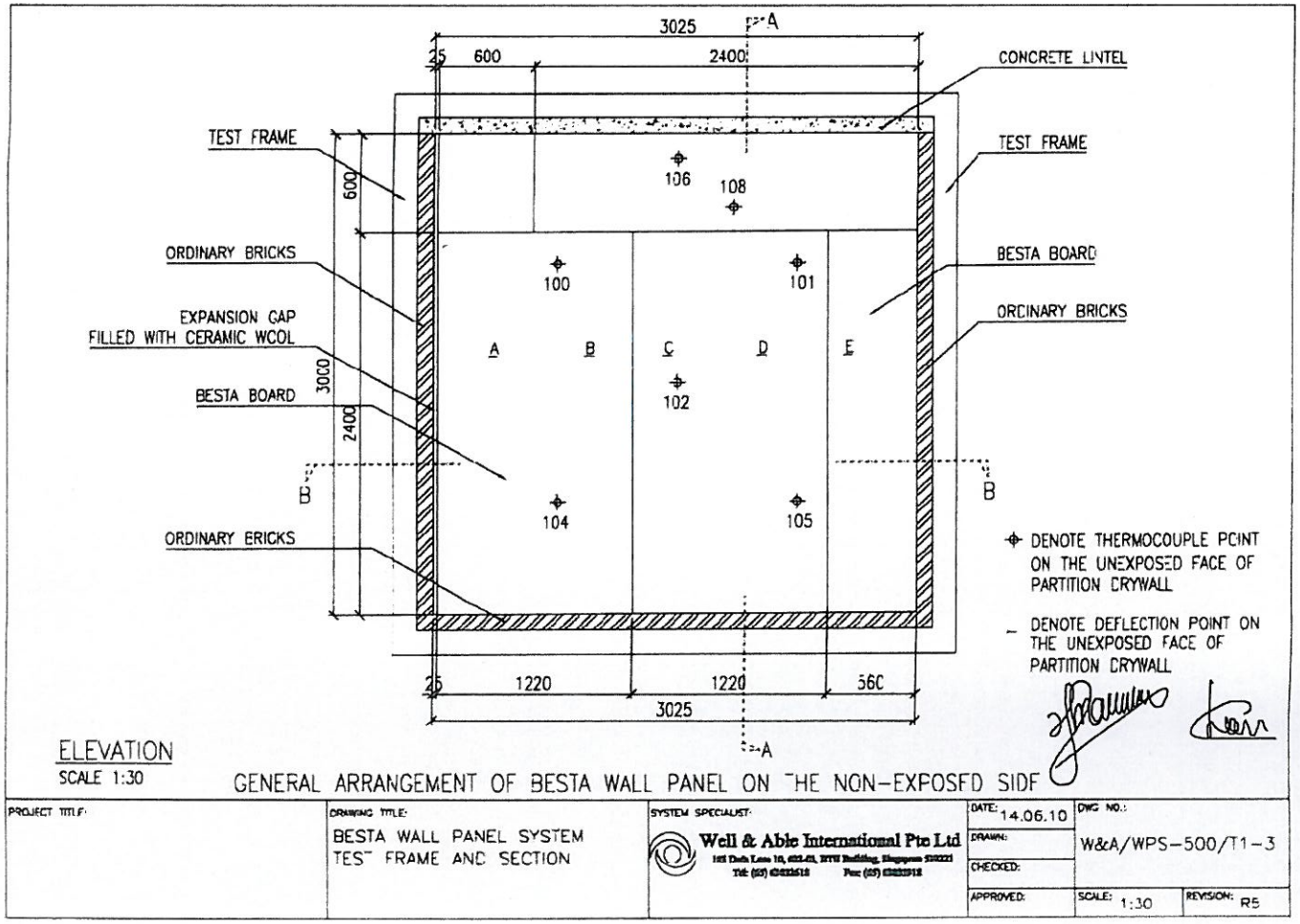


System Component	Description
A	12mm Besta Board
B	50mm thk SFF Rockwool (40kg/m3)
C	40x50x40x0.6mm thk U stud @ Top and Bottom
D	50x50x50x0.6mm thk U stud @ 500mm c/c
E	Self drilling Screw ø5.8mm 25mmL @500mm c/c
F	Self drilling Screw ø3.5mm 25mmL @400mm c/c
G	GX-Adhesive 282
H	GX-Cote059w (Powder and Liquid)
I	Fire-Retardant Silicone Sealant, HC-119

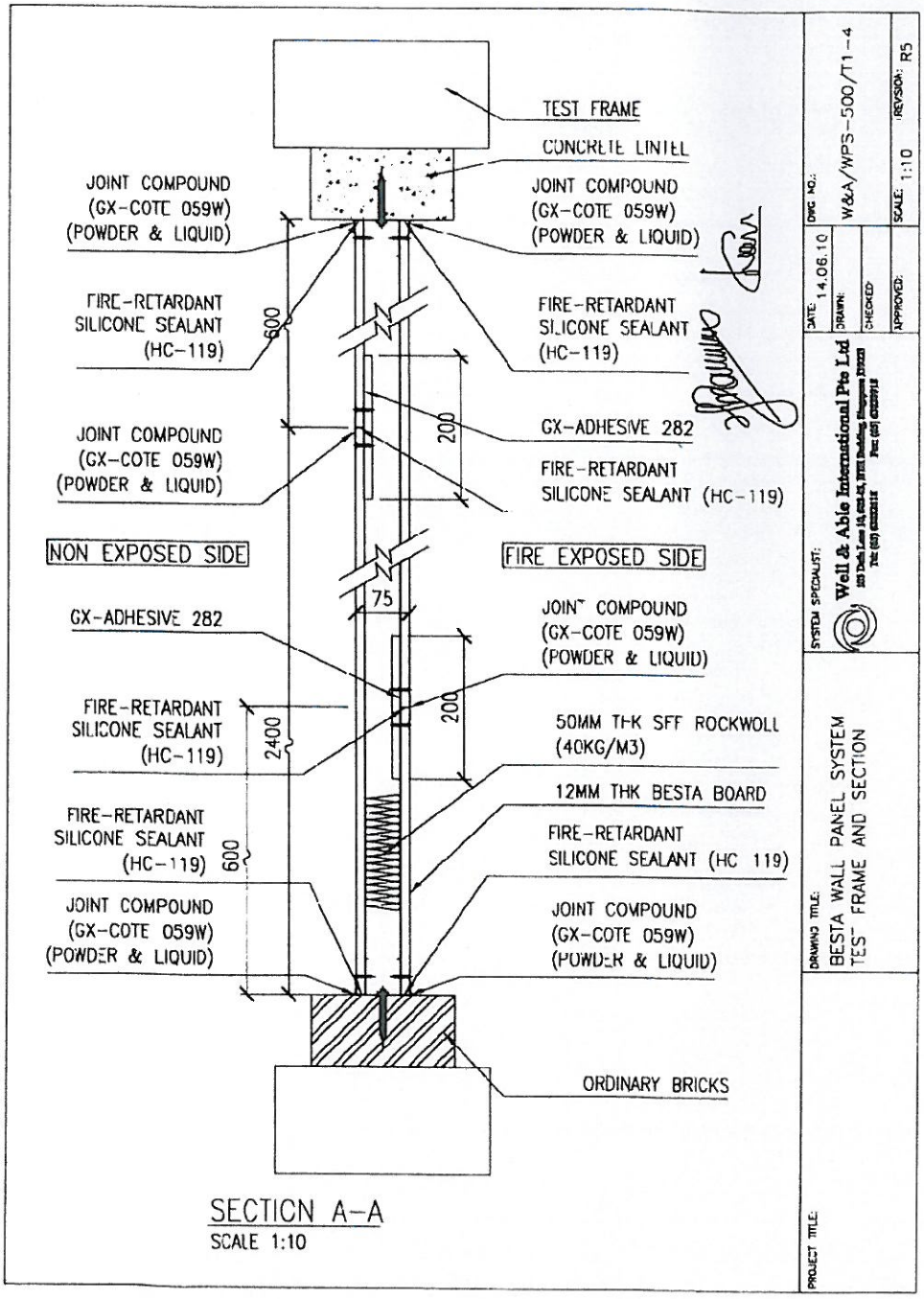
PROJECT TITLE:	DRAWING TITLE:	SYSTEM SPECIALIST:	DATE: 14.06.10	DWG NO.:
	BESTA WALL PANEL SYSTEM ISOMETRIC VIEW	Well & Able International Pte Ltd	DRAWN:	W&A/WPS 500/T1 1
			CHECKED:	
			APPROVED:	SCALE: NTS REVISION: R5

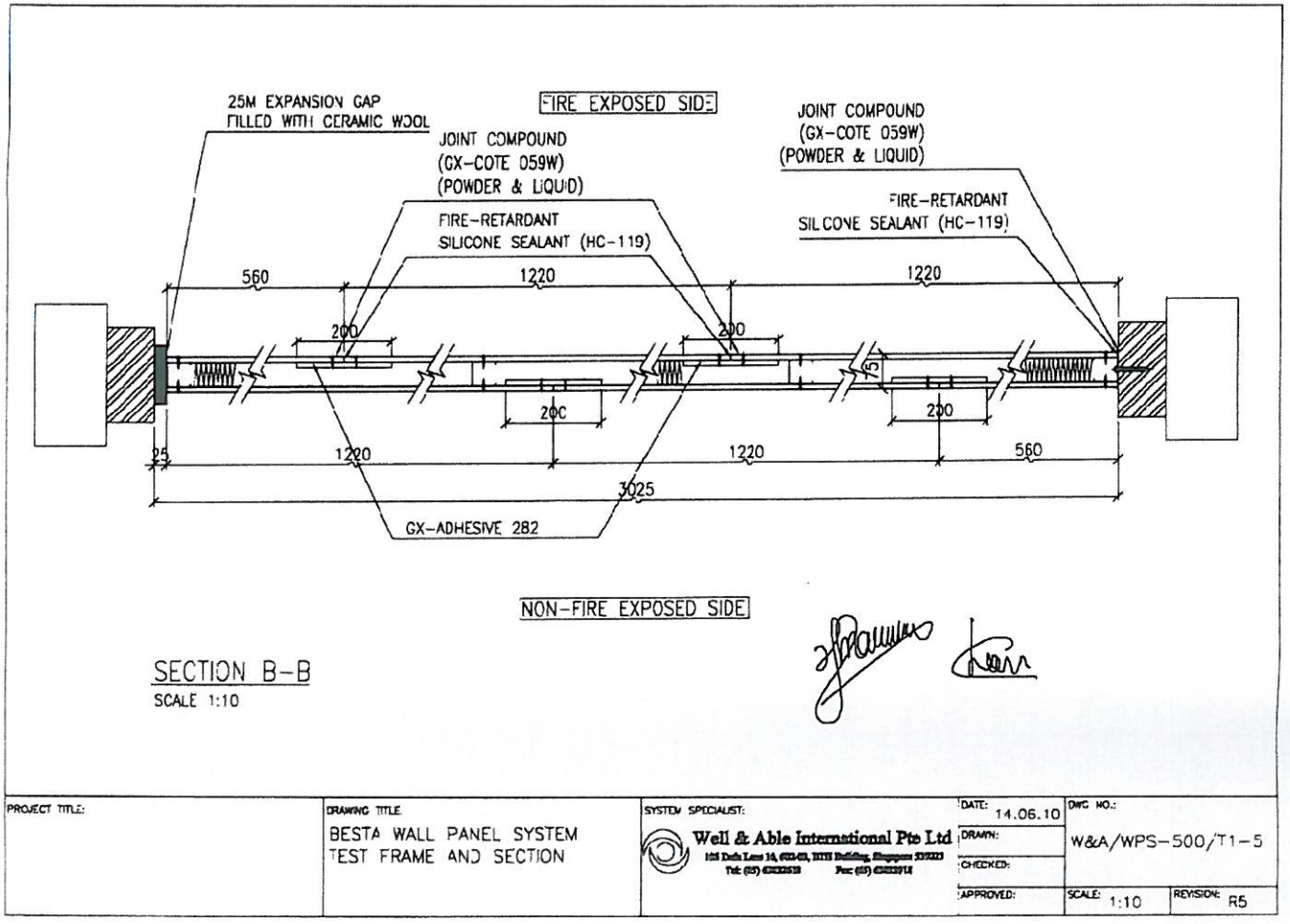
PSB Singapore




3025
25
600
2400
CONCRETE LINTEL
TEST FRAME
TEST FRAME
600
106
108
ORDINARY BRICKS
BESTA BOARD
100
101
EXPANSION GAP
FILLED WITH CERAMIC WOOL
ORDINARY BRICKS
A
B
C
D
E
3000
BESTA BOARD
2400
102
B
B
104
105
ORDINARY ERICKS
DENOTE THERMOCOUPLE POINT ON THE UNEXPOSED FACE OF PARTITION DRYWALL
DENOTE DEFLECTION POINT ON THE UNEXPOSED FACE OF PARTITION DRYWALL
25
1220
1220
560
3025
A
A
ELEVATION
SCALE 1:30
GENERAL ARRANGEMENT OF BESTA WALL PANEL ON THE NON-EXPOSED SIDE
PROJECT TITLE:
DRAWING TITLE:
BESTA WALL PANEL SYSTEM
TEST FRAME AND SECTION
SYSTEM SPECIALIST:
Well & Able International Pte Ltd
DATE: 14.06.10
DWG NO.:
W&A/WPS-500/T1-3
DRAWN:
CHECKED:
APPROVED:
SCALE: 1:30
REVISION: R5

Test Report No. 719178407-MEC10-MW
dated 22 Jun 2010

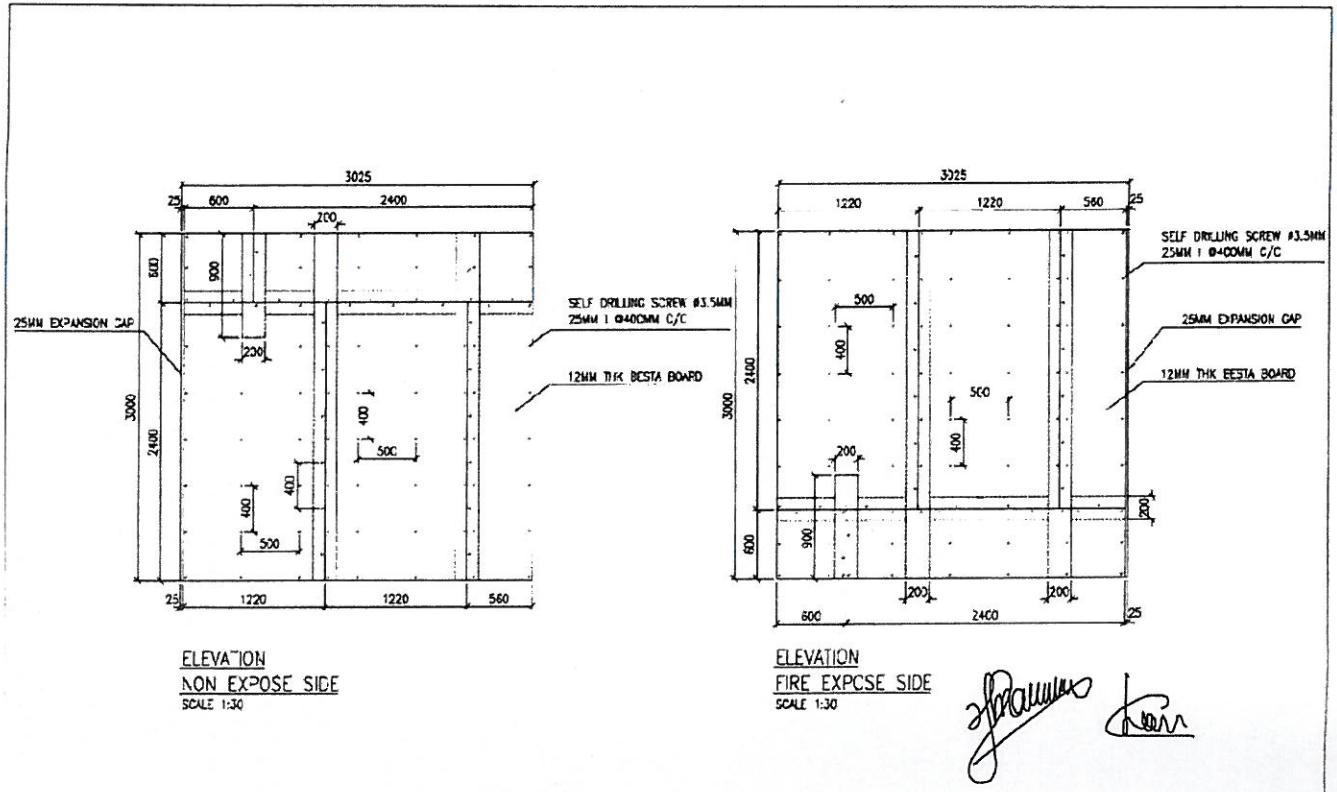




SECTION B-B
SCALE 1:10

PROJECT TITLE:	DRAWING TITLE: BESTA WALL PANEL SYSTEM TEST FRAME AND SECTION	SYSTEM SPECIALIST: Well & Able International Pte Ltd	DATE: 14.06.10	DWG NO.: W&A/WPS-500/T1-5
			DRAWN:	
			CHECKED:	
			APPROVED:	SCALE: 1:10 / REVISION: R5

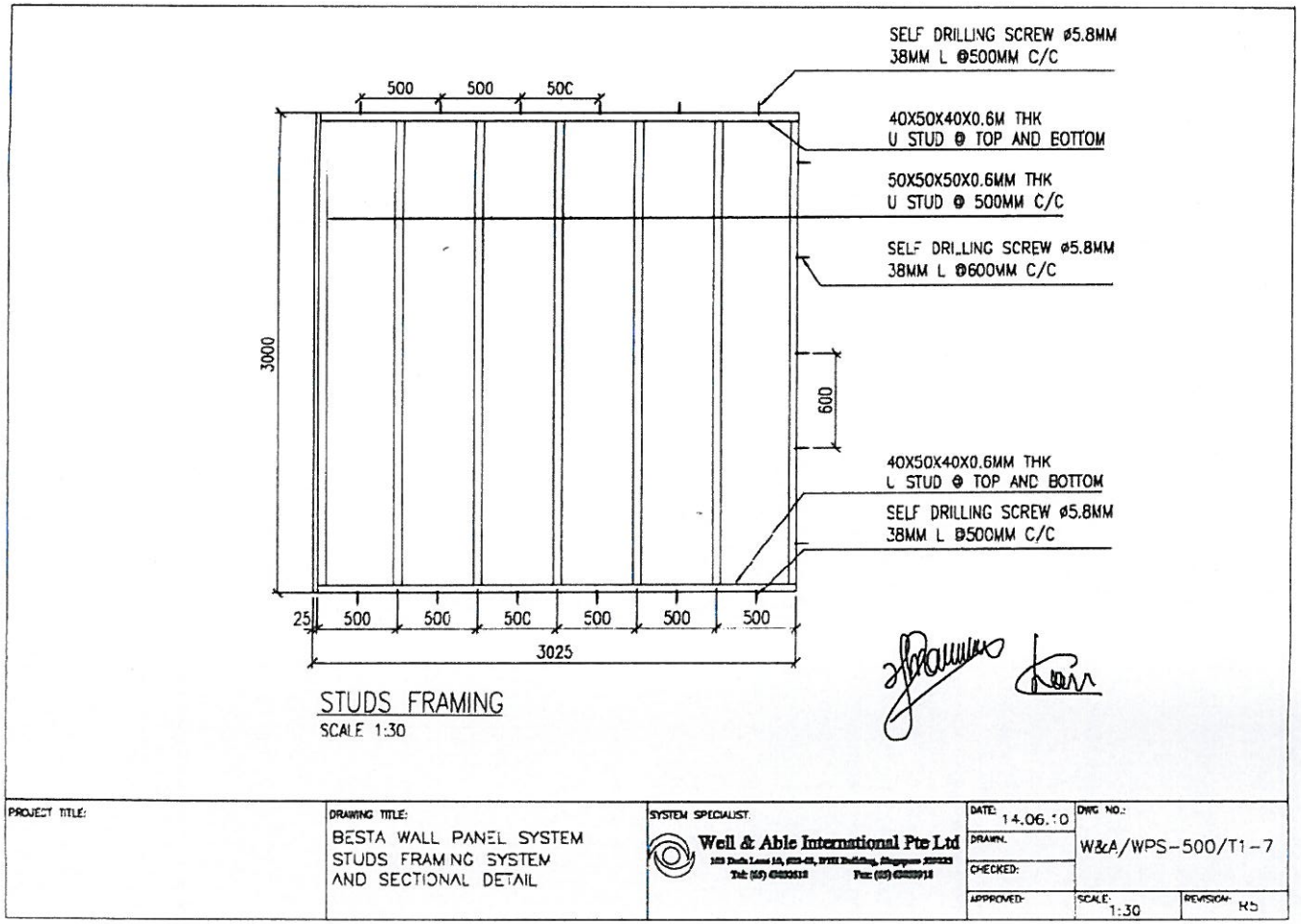
PSB Singapore



ELEVATION
NON EXPOSE SIDE
SCALE 1:30

ELEVATION
FIRE EXPOSE SIDE
SCALE 1:30

PROJECT TITLE:	DRAWING TITLE: BESTA WALL PANEL SYSTEM BOARD ELEVATION FIRE EXPOSED SIDE AND NON EXPOSED SIDE	SYSTEM SPECIALIST: Well & Able International Pte Ltd	DATE: 14.05.10	DWG NO.: W&A/WPS-500/T*-6
			DRAWN:	
			CHECKED:	
			APPROVED:	SCALE: 1:40 REVISION: R5


SELF DRILLING SCREW ø5.8MM
38MM L @500MM C/C
40X50X40X0.6M THK
U STUD @ TOP AND BOTTOM
50X50X50X0.6MM THK
U STUD @ 500MM C/C
SELF DRILLING SCREW ø5.8MM
38MM L @600MM C/C
40X50X40X0.6MM THK
L STUD @ TOP AND BOTTOM
SELF DRILLING SCREW ø5.8MM
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STUDS FRAMING
SCALE 1:30
PROJECT TITLE:
DRAWING TITLE:
BESTA WALL PANEL SYSTEM
STUDS FRAMING SYSTEM
AND SECTIONAL DETAIL
SYSTEM SPECIALIST:
Well & Able International Pte Ltd
DATE: 14.06.10
DRAWN:
CHECKED:
APPROVED:
DWG NO.:
W&A/WPS-500/T1-7
SCALE: 1:30
REVISION: R5

PSB Singapore

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March 2010

b2) Fire Resistance Test On A Non Load Bearing Besta Wall Panel

Test Report No. S08MEC05926/LGJ
dated 04 Oct 2008

PSB Singapore

Note: This report is issued subject to TÜV SÜD PSB's "Terms and Conditions Governing Technical Services". The terms and conditions governing the issue of this report are set out as attached within this report.

Choose certainty.
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SUBJECT:

Non-combustibility test on "BESTA" Fire Resistant Board material submitted by Best Rock Building Systems Pte Ltd on 17 Sep 2008.

TESTED FOR:

Best Rock Building Systems Pte Ltd
14 Zion Road
Singapore 247732

Attn: Mr Daniel Wong

DATE OF TEST:

30 Sep 2008

PURPOSE OF TEST:

To determine whether the material is non-combustible when it is exposed to the conditions of the test specified in British Standard 476: Part 4: 1970 "Fire Test on Building Materials and Structures - Non-combustibility Test for Materials".
The test was conducted at TÜV SÜD PSB fire test laboratory located at No. 10 Tuas Avenue 10, Singapore 639134.

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LA-2007-0380-A
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LA-2007-0383-G
LA-2007-0384-G
LA-2007-0385-E
LA-2007-0386-C

The results reported herein have been performed in accordance with the laboratory's terms of accreditation under the Singapore Accreditation Council - Singapore Laboratory Accreditation Scheme. Tests/Calibrations marked "Not SAC-SINGLAS Accredited" in this Report are not included in the SAC-SINGLAS Accreditation Schedule for our laboratory.

Laboratory:
TÜV SÜD PSB Pte. Ltd.
Testing Services
No 1 Science Park Drive
Singapore 118221

Phone : +65-6885 1333
Fax : +65-6776 8670
E-mail: testing@tuv-sud-psb.sg
www.tuv-sud-psb.sg
Co. Reg : 199002667R

Regional Head Office:
TÜV SÜD Asia Pacific Pte. Ltd.
3 Science Park Drive, #04-01/05
The Franklin, Singapore 118223
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DESCRIPTION OF SAMPLES:

6 pieces of sample, said to be "BESTA" Fire Resistant Board material comprising of Magnesium Oxide composite mineral board, each of nominal size of 40mm x 40mm x 50mm thickness were received. The overall bulk density of the sample was found be about 1253kg/m^3.

TEST PROCEDURE:

Specimens were exposed to the specified heating conditions (750 ± 10°C) in a furnace conforming to Clause 6 and illustrated in Figure 1, 2 and 3 of the Standard. The furnace was heated and its temperature stabilized at 750 ± 10°C for more than 10 minutes. One specimen was then inserted in the furnace, the whole operation was performed in less than 5 seconds. The temperature of the specimens and the furnace were measured by two separate Chromel/Alumel thermocouples continuously for 20 minutes on the chart of a recorder. The flaming time of the specimen was determined by a stop watch. The procedure was repeated twice for two other specimens, one at each time.

RESULTS:

Description	Specimen 1	Specimen 2	Specimen 3	Requirements
Time of continuous flaming (sec.)	0	0	0	<10
Temperature rise of furnace (°C)	0	5	6	<50
Temperature rise of sample (°C)	0	0	0	<50
Classification	Non-combustible	Non-combustible	Non-combustible	-

CONCLUSION:

A non-combustibility test for materials in accordance with British Standard 476 Part 4 : 1970 has been performed on the material as described in this report and the classification of the sample is non-combustible.

Ong Kian Huat
Associate Engineer

Chan Lung Toa
Product Manager
(Fire Safety & Security Products)
Mechanical

Report is issued under the following conditions:

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January 2008

c) Thermal Conductivity Test Report

SETSCO SERVICES PTE LTD
18 Teban Gardens Crescent
Singapore 608925
Tel : (65) 6566 7777
Fax: (65) 6566 7718
Website: www.setsco.com
Business Reg. No. 196900269D

TEST REPORT

(This Report is issued subject to the terms & conditions set out below)

Your Ref: - Quotation SPD/ thc2008/ dw003R dd 17th April 2008
Our Ref: SP- 2 (3) /THC

Date: 19/09/2008

Subject : Determination of Thermal Conductivity Value of "BESTA" Mangnesium Oxide (MgO) board & sandwitch systems, submitted by Best Rock Building Systems Pte Ltd on 11/07 /2008.

Tested For : M/s Best Rock Building Systems PTE LTD
14 Zion Road
Singapore 247732
Attn: Mr. Daniel Wong

Method of Test : Thermal Conductivity : ASTM C 518-05

Description of Sample : "BESTA" Magnesium Oxide (MgO) sandwich panels, consists of 2 nos each of : 1) 300 x 300 x 10mm MgO board; 2) 300 x 300 x 100mm sandwich perlite panel; & 3) 600 x 600 x 128mm sandwich perlite w/air channel panel system were received (see photographs 1 & 2).

Thermal Conductivity Test

Samples Reference	"BESTA" MgO board / sandwich panel		
	MgO board	100mm sandwich (10mm+80mm Perlite+10) panel	128mm sandwich (10mm+80mm Perlite+10+18mm board w/partial air section+10mm) panel
Dimension of test specimens (mm)	300 x 300x 10	300 x 300 x 100	600 x 600 x 128
Date of test	20/08/08		
Mean sample temperature (°C)	30		
Thermal conductivity (W/m.k)	0.132	0.133	0.196

Yip Poh Chuan
Testing Officer
Special Project Department

Tan Hong Choon
Asst. Manager
Special Project Department

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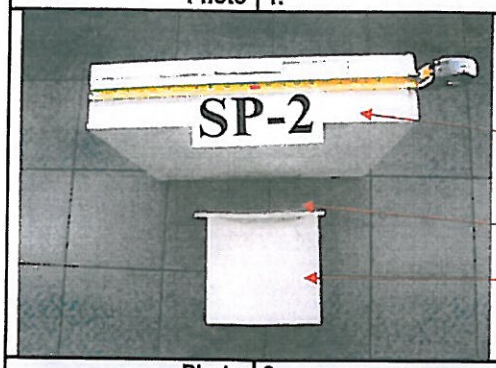
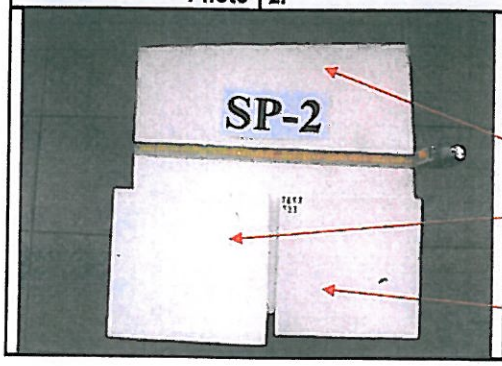
	Physical and Mechanical Properties –Thermal conductivity test specimens : 600 x 600 x 128 mm Sandwich perlite w/air channel panel. 300 x 300 x 10 mm MgO board. 300 x 300 x 100 mm Sandwich perlite panel.
Photo 2.	
	Physical and Mechanical Properties –Thermal conductivity test specimens : 600 x 600 x 128 mm Sandwich perlite w/air channel panel. 300 x 300 x 100 mm Sandwich perlite panel. 300 x 300 x 10 mm MgO board.

d) Sound Insulation Test Report

d1) Laboratory Measurement of Airborne Sound Transmission Loss

Test Report No. S08MEC04781/A2/EMK
dated 18 Aug 2008

PSB Singapore

Choose certainty.
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Note: This report is issued subject to TÜV SÜD PSB's "Terms and Conditions Governing Technical Services". The terms and conditions governing the issue of this report are set out as attached within this report.

SUBJECT:

Laboratory measurement of airborne sound transmission loss of "Besta" composite mineral board system submitted by Best Rock Building Systems Pte Ltd on 4 Aug 2008.

TESTED FOR:

Best Rock Building Systems Pte Ltd
14 Zion Road
Singapore 247732

Attn : Mr Daniel Wong

DATE OF TEST:

8 Aug 2008

DESCRIPTION OF SAMPLES:

The "Besta" composite mineral board system of 3.20m (width) x 3.15m (length) x 100mm (thick) was installed onto the sample carrier by Best Rock Building Systems Pte Ltd.

The dimension of each composite mineral board was 3145mm (length) x 600mm (width) x 100mm (thick). Each composite mineral board consisted of Perlite materials enclosed by 10mm thick "Besta" board. The mass of each composite mineral board measured to be 93kg.

The joining of panel-to-panel and the perimeter seal of the composite mineral board system was used by silicone sealant.

The drawing description of the composite mineral board system was shown in Figure 4.

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LA-2007-0385-E
LA-2007-0386-C
The results reported herein have been performed in accordance with the laboratory's terms of accreditation under the Singapore Accreditation Council - Singapore Laboratory Accreditation Scheme. Tests/Calibrations marked "Not SAC-SINGLAS Accredited" in this Report are not included in the SAC-SINGLAS Accreditation Schedule for our laboratory

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TÜV SÜD PSB Pte. Ltd.
Testing Services
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E-mail: testing@tuv-sud-psb.sg
www.tuv-sud-psb.sg
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Regional Head Office:
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3 Science Park Drive, #04-01/05
The Franklin, Singapore 118223
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METHOD OF TEST:

The test was conducted in accordance with ASTM E90 - 04 "Standard test method for laboratory measurement of airborne sound transmission loss of building partitions and elements"

Measured area of panel opening: 3.20m (width) x 3.15m (height) = 10.06m^2
Air temperature in both source room and receiving room : 26°C
Relative air humidity in both source room and receiving room : 65%
Source room volume : 74m^3
Receiving room volume : 84m^3
Location of the test : Acoustics Lab of TÜV SÜD PSB Pte Ltd

TEST EQUIPMENT:

The following instruments were used for the test.

1) A dual-channel real-time frequency analyser (B&K Type 2133)
2) Two units of loudspeaker (JBL MPro MP415)
3) Two sets of ½" condenser microphones (B&K Type 4190)
4) Two sets of microphone preamplifers (B&K Type 2669)
5) A sound pressure level calibrator (Norsonic Type 1251)
6) A sound source amplifier (Crown model CE 1000)
7) Two sets of rotating microphone booms (B&K Type 3923)

TEST PROCEDURES:

1) Instrumentation was set up according to ASTM E90.

2) Measurement system was calibrated using a sound level calibrator Norsonic Type 1251.

3) Background noise level for both source room and receiving room were measured.

4) Sound source system was switched on and maintained at constant level. The sound pressure level in the receiving room was ensured to be 15dB higher than the background noise level.

5) Recording time for both rotating microphone booms was set to 64s which equals to the time taken by the booms to complete two revolutions.

6) Sound pressure level difference between the source room and the receiving room was measured with a dual – channel acoustic analyser (B&K 2133), and the measurement was repeated thrice.

7) Step 6 was repeated after the loudspeaker was moved to new position.

8) Reverberation time (RT) of the receiving room was measured from two different loudspeaker positions. Each loudspeaker position was measured twice.

9) The mean values of the six readings for sound pressure level difference and four readings for RT values were calculated.

10) Values of sound reduction index were determined for each 1/3 octave frequency band from 100Hz to 5kHz based on the mean values of step 9.

11) Sound transmission class was determined at the frequency of 500Hz of the shifted reference curve according to ASTM E413

PSB Singapore

RESULTS:

Values of sound transmission loss (TL) of the tested sample were tabulated in Table 1. Sound insulation rating was computed according to ASTM E413 - 04 "Classification for rating sound insulation".

Table 1 : Measured Sound Transmission Loss, TL and values of the shifted reference curve for STC = 36

1/3 Octave Band Frequency (Hz)	Measured Sound Transmission Loss, TL (dB)	Shifted Reference Curve STC = 36 (dB)	Deficiency
100	30.0	17.0	0.0
125	27.9	20.0	0.0
160	30.2	23.0	0.0
200	29.8	26.0	0.0
250	29.3	29.0	0.0
315	30.1	32.0	1.9
400	31.7	35.0	3.3
500	34.2	36.0	1.8
630	35.6	37.0	1.4
800	36.3	38.0	1.7
1000	36.6	39.0	2.4
1250	36.8	40.0	3.2
1600	37.3	40.0	2.7
2000	37.6	40.0	2.4
2500	37.4	40.0	2.6
3150	38.7	40.0	1.3
4000	41.4	40.0	0.0
5000	44.9	40.0	0.0
	Total deficiency (125Hz – 4000Hz) :		25

The values in Table 1 were plotted as shown in Figure 1.

Remark:

The tested "Besta" composite mineral board system achieved sample has a sound transmission class, STC = 36

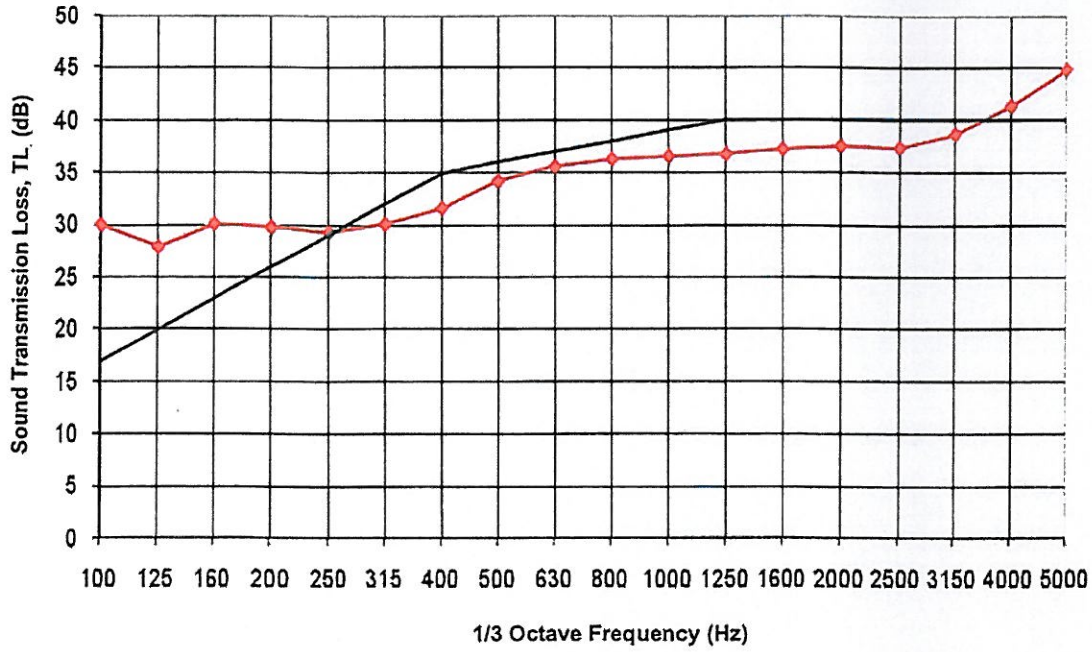
Francis Ee Min Kuen
Testing Officer

Dr Sun Qiqing
Assistant Vice President
Acoustics & Vibration
Testing Services

PSB Singapore

RESULTS: (cont'd)

Figure 1 : Sound transmission performance of "Besta" composite mineral board system



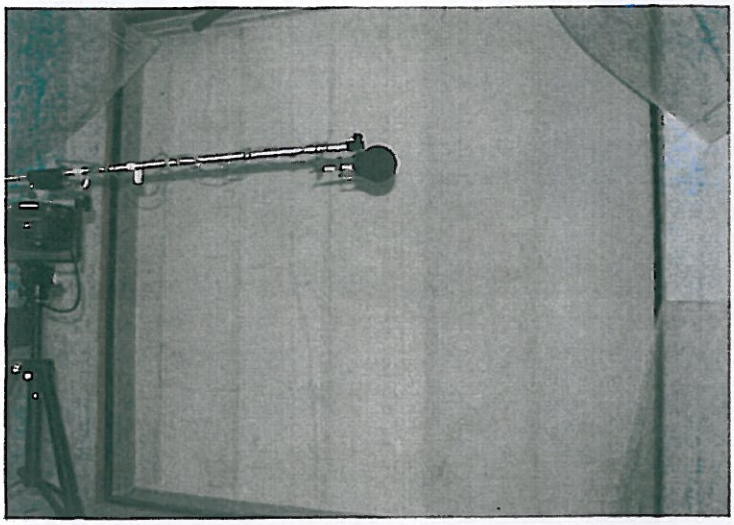


Figure 2 : "Besta" composite mineral board system facing the source room

Figure 3 : "Besta" composite mineral board system facing the receiving room

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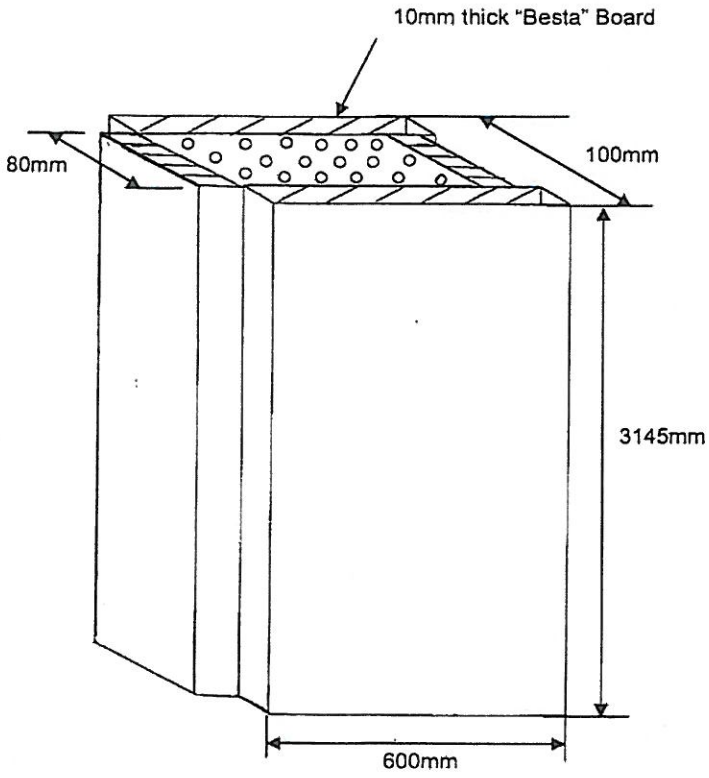

Figure 4 : "Besta" composite mineral board panel

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January 2008

d2) Laboratory Measurement of Airborne Sound Insulation

Test Report No. S08MEC04781/A1/EMK
dated 18 Aug 2008

PSB Singapore

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Note: This report is issued subject to TÜV SÜD PSB's "Terms and Conditions Governing Technical Services". The terms and conditions governing the issue of this report are set out as attached within this report.

SUBJECT:

Laboratory measurement of airborne sound insulation of "Besta" composite mineral board system submitted by Best Rock Building Systems Pte Ltd on 4 Aug 2008.

TESTED FOR:

Best Rock Building Systems Pte Ltd
14 Zion Road
Singapore 247732

Attn : Mr Daniel Wong

DATE OF TEST:

8 Aug 2008

DESCRIPTION OF SAMPLES:

The "Besta" composite mineral board system of 3.20m (width) x 3.15m (length) x 100mm (thick) was installed onto the sample carrier by Best Rock Building Systems Pte Ltd.

The dimension of each composite mineral board was 3145mm (length) x 600mm (width) x 100mm (thick). Each composite mineral board consisted of Perlite materials enclosed by 10mm thick "Besta" board. The mass of each composite mineral board measured to be 93kg.

The joining of panel-to-panel and the perimeter seal of the composite mineral board system was used by silicone sealant.

The drawing description of the composite mineral board system was shown in Figure 4.

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LA-2007-0384-G
LA-2007-0385-E
LA-2007-0386-C
The results reported herein have been performed in accordance with the laboratory's terms of accreditation under the Singapore Accreditation Council - Singapore Laboratory Accreditation Scheme. Tests/Calibrations marked "Not SAC-SINGLAS Accredited" in this Report are not included in the SAC-SINGLAS Accreditation Schedule for our laboratory.

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Co Reg 199002667R

Regional Head Office:
TÜV SÜD Asia Pacific Pte. Ltd.
3 Science Park Drive, #04-01/05
The Franklin Singapore 118223

METHOD OF TEST:

The test was conducted in accordance with ISO 140 – 3 : 1995 "Laboratory measurements of airborne sound insulation of building elements".

Measured area of panel opening: 3.20m (width) x 3.15m (height) = 10.06m^2
Air temperature in both source room and receiving room : 26°C
Relative air humidity in both source room and receiving room : 65%
Source room volume : 74m^3
Receiving room volume : 84m^3
Location of the test : Acoustics Lab of TÜV SÜD PSB Pte Ltd

TEST EQUIPMENT:

The following instruments were used for the test.

1) A dual-channel real-time frequency analyser (B&K Type 2133)
2) Two units of loudspeaker (JBL MPro MP415)
3) Two sets of ½" condenser microphones (B&K Type 4190)
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5) A sound pressure level calibrator (Norsonic Type 1251)
6) A sound source amplifier (Crown model CE 1000)
7) Two sets of rotating microphone booms (B&K Type 3923)

TEST PROCEDURES:

1) Instrumentation was set up according to ISO 140 - 3.

2) Measurement system was calibrated using a sound level calibrator Norsonic Type 1251.

3) Background noise level for both source room and receiving room were measured.

4) Sound source system was switched on and maintained at constant level. The sound pressure level in the receiving room was ensured to be 15dB higher than the background noise level.

5) Recording time for both rotating microphone booms was set to 64s which equals to the time taken by the booms to complete two revolutions.

6) Sound pressure level difference between the source room and the receiving room was measured with a dual – channel acoustic analyser (B&K 2133), and the measurement was repeated 3 times.

7) Step 6 was repeated after the loudspeaker was moved to new position.

8) Reverberation time (RT) of the receiving room was measured from two different loudspeaker positions. Each loudspeaker position was measured 2 times.

9) The mean values of the six readings for sound pressure level difference and four readings for RT values were calculated.

10) Values of sound reduction index were determined for each 1/3 octave frequency band from 100Hz to 5kHz based on the mean values of step 9.

11) Weighted sound reduction index (R_w) (single number for rating sound insulation of the sample) and its adaptation terms (C, C_{tr}) according to ISO 717-1 was determined at the frequency of 500Hz of the shifted reference curve (see figure 1)

RESULTS:

Values of sound reduction index (R) of the tested sample were tabulated in Table 1. Sound Insulation Rating is computed according to ISO 717 - 1 : 1996 "Acoustics - Rating of sound insulation in buildings and of building elements – Part 1: Airborne sound insulation".

Table 1 : Measured values of the test sample and values of the shifted reference curve for $R_w = 36$

1/3 Octave Band Frequency (Hz)	Measured Sound Reduction Index, R (dB)		Shifted Reference Curve $R_w = 36$ (dB)	Deficiency
100	30.0	29	17.0	0.0
125	27.9		20.0	0.0
160	30.2		23.0	0.0
200	29.8	30	26.0	0.0
250	29.3		29.0	0.0
315	30.1		32.0	1.9
400	31.7	34	35.0	3.3
500	34.2		36.0	1.8
630	35.6		37.0	1.4
800	36.3	37	38.0	1.7
1000	36.6		39.0	2.4
1250	36.8		40.0	3.2
1600	37.3	37	40.0	2.7
2000	37.6		40.0	2.4
2500	37.4		40.0	2.6
3150	38.7	41	40.0	1.3
4000	41.4		40.0	0.0
5000	44.9		40.0	0.0
Total deficiency (100Hz – 3150Hz) :				25

The values in Table 1 were plotted as shown in Figure 1.

Remark:

The tested "Besta" composite mineral board system achieved a weighted sound reduction index, $R_w (C, C_{tr}) = 36 (0, -2)$.

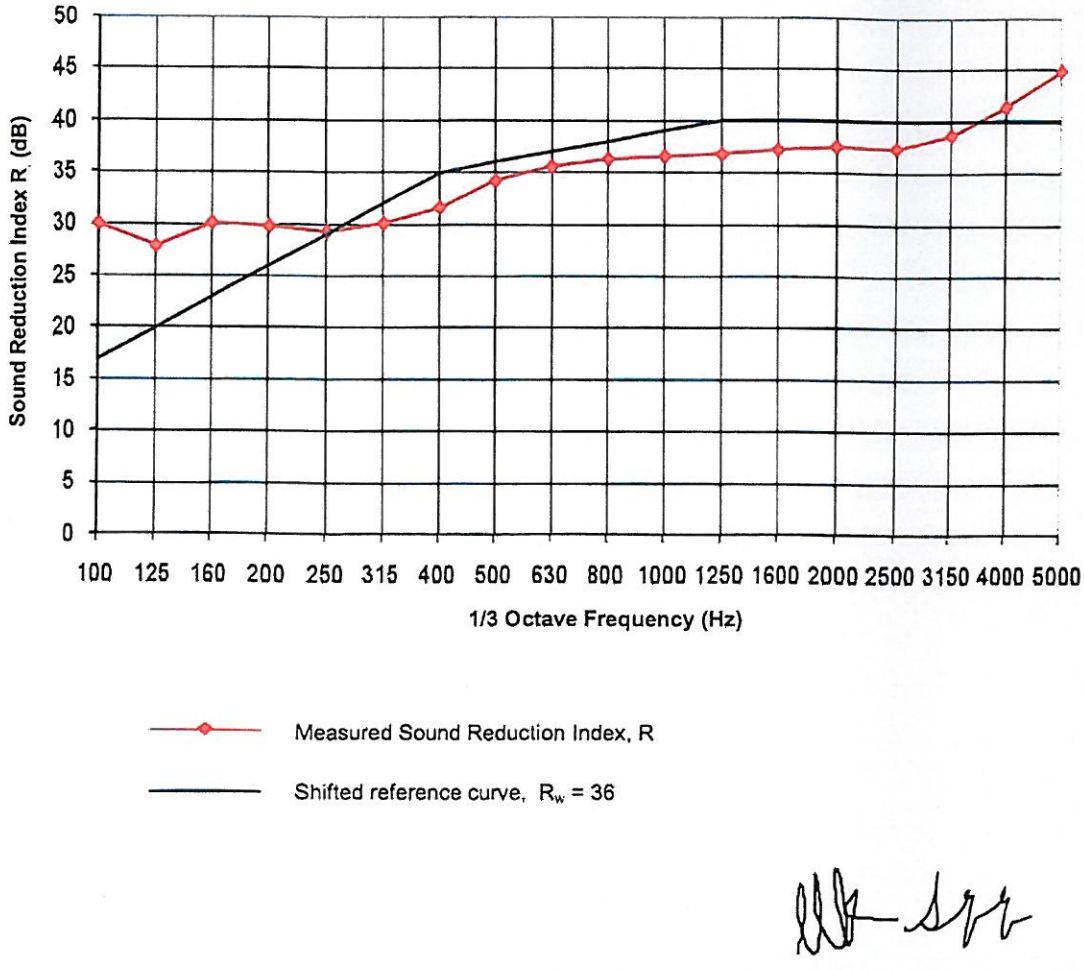
Francis Ee Min Kuen
Testing Officer

Dr Sun Qiqing
Assistant Vice President
Acoustics & Vibration
Testing Services

PSB Singapore

RESULTS: (cont'd)

Figure 1 : Sound insulation performance of "Besta" composite mineral board system



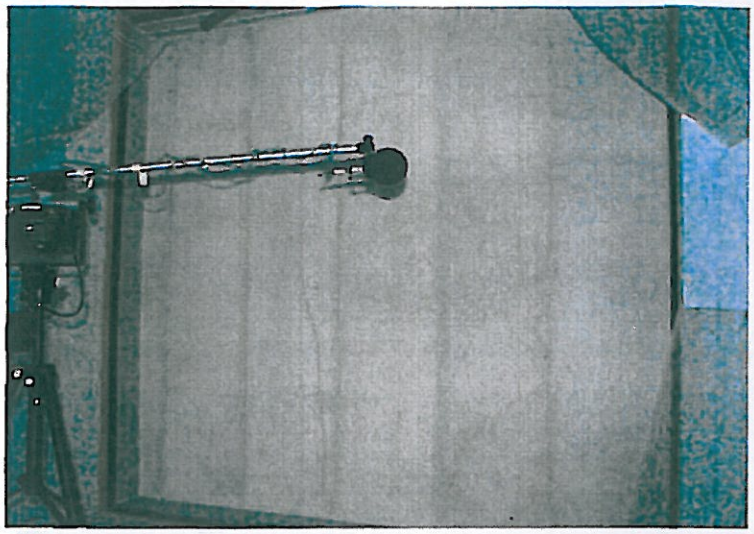


Figure 2 : "Besta" composite mineral board system facing the source room

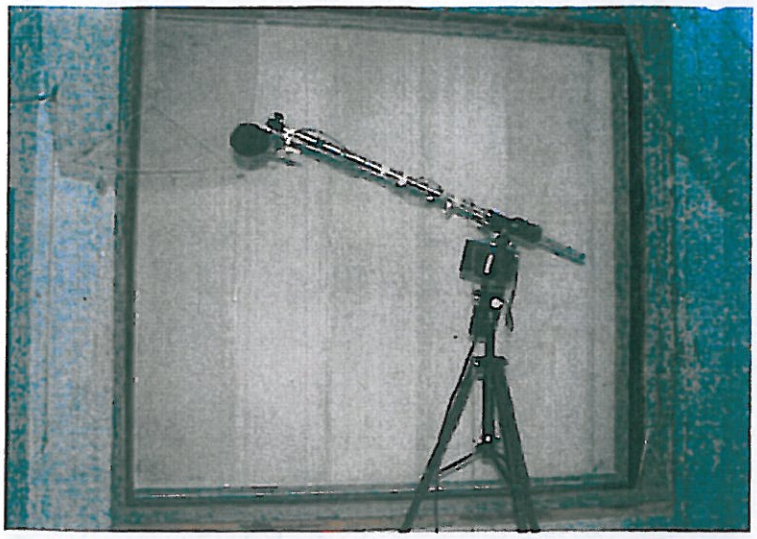


Figure 3 : "Besta" composite mineral board system facing the receiving room

PSB Singapore

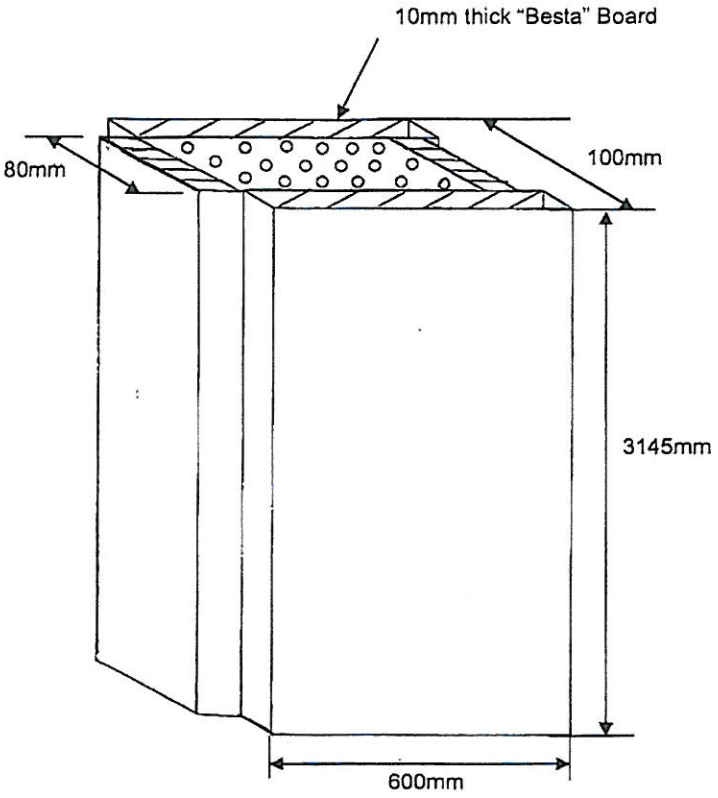


Figure 4 : "Besta" composite mineral board panel

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January 2008

d3) Laboratory Measurement of Impact Sound Insulation

Test Report No. S08MEC04781/B/EMK
dated 18 Aug 2008

PSB Singapore

Choose certainty.
Add value.

Note: This report is issued subject to TÜV SÜD PSB's "Terms and Conditions Governing Technical Services". The terms and conditions governing the issue of this report are set out as attached within this report.

SUBJECT:

Laboratory measurement of impact sound insulation of "Besta" board panel system submitted by Best Rock Building Systems Pte Ltd on 4 Aug 2008.

TESTED FOR:

Best Rock Building Systems Pte Ltd
14 Zion Road
Singapore 247732

Attn : Mr Daniel Wong

DATE OF TEST:

12 Aug 2008

DESCRIPTION OF SAMPLES:

The "Besta" board panel system was installed on the horizontal opening of the receiving room for impact sound transmission test by Best Rock Building Systems Pte Ltd.

The "Besta" board panel system was consisted of 6 pieces of board panel. Each board panel comprised of 1 piece of 12mm thick "Besta" board and 1 piece 18mm thick "Besta" board bonded together with contact adhesive (dunlop glue).

The joining of panel-to-panel and the perimeter seal of the composite mineral board system was used by silicone sealant.

The technical drawing of the board panel system was shown in Figure 4.

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Regional Head Office:
TÜV SÜD Asia Pacific Pte. Ltd.
3 Science Park Drive, #04-01/05
The Franklin, Singapore 118223
TÜV

METHOD OF TEST:

The test was conducted in accordance with ISO 140 – 3 : 1995 "Laboratory measurements of airborne sound insulation of building elements".

Measured area of panel opening: 3.20m (width) x 3.15m (height) = 10.06m^2
Air temperature in both source room and receiving room : 26°C
Relative air humidity in both source room and receiving room : 65%
Source room volume : 74m^3
Receiving room volume : 84m^3
Location of the test : Acoustics Lab of TÜV SÜD PSB Pte Ltd

TEST EQUIPMENT:

The following instruments were used for the test.

1) A dual-channel real-time frequency analyser (B&K Type 2133)
2) Two units of loudspeaker (JBL MPro MP415)
3) Two sets of ½" condenser microphones (B&K Type 4190)
4) Two sets of microphone preamplifers (B&K Type 2669)
5) A sound pressure level calibrator (Norsonic Type 1251)
6) A sound source amplifier (Crown model CE 1000)
7) Two sets of rotating microphone booms (B&K Type 3923)

TEST PROCEDURES:

1) Instrumentation was set up according to ISO 140 - 3.

2) Measurement system was calibrated using a sound level calibrator Norsonic Type 1251.

3) Background noise level for both source room and receiving room were measured.

4) Sound source system was switched on and maintained at constant level. The sound pressure level in the receiving room was ensured to be 15dB higher than the background noise level.

5) Recording time for both rotating microphone booms was set to 64s which equals to the time taken by the booms to complete two revolutions.

6) Sound pressure level difference between the source room and the receiving room was measured with a dual – channel acoustic analyser (B&K 2133), and the measurement was repeated 3 times.

7) Step 6 was repeated after the loudspeaker was moved to new position.

8) Reverberation time (RT) of the receiving room was measured from two different loudspeaker positions. Each loudspeaker position was measured 2 times.

9) The mean values of the six readings for sound pressure level difference and four readings for RT values were calculated.

10) Values of sound reduction index were determined for each 1/3 octave frequency band from 100Hz to 5kHz based on the mean values of step 9.

11) Weighted sound reduction index (R_w) (single number for rating sound insulation of the sample) and its adaptation terms (C, C_{tr}) according to ISO 717-1 was determined at the frequency of 500Hz of the shifted reference curve (see figure 1)

PSB Singapore

RESULTS:

Values of sound reduction index (R) of the tested sample were tabulated in Table 1. Sound Insulation Rating is computed according to ISO 717 - 1 : 1996 "Acoustics - Rating of sound insulation in buildings and of building elements – Part 1: Airborne sound insulation".

Table 1 : Measured values of the test sample and values of the shifted reference curve for R_w = 36

1/3 Octave Band Frequency (Hz)	Measured Sound Reduction Index, R (dB)		Shifted Reference Curve R_w = 36 (dB)	Deficiency
100	30.0	29	17.0	0.0
125	27.9		20.0	0.0
160	30.2		23.0	0.0
200	29.8	30	26.0	0.0
250	29.3		29.0	0.0
315	30.1		32.0	1.9
400	31.7	34	35.0	3.3
500	34.2		36.0	1.8
630	35.6		37.0	1.4
800	36.3	37	38.0	1.7
1000	36.6		39.0	2.4
1250	36.8		40.0	3.2
1600	37.3	37	40.0	2.7
2000	37.6		40.0	2.4
2500	37.4		40.0	2.6
3150	38.7	41	40.0	1.3
4000	41.4		40.0	0.0
5000	44.9		40.0	0.0
Total deficiency (100Hz – 3150Hz) :				25

The values in Table 1 were plotted as shown in Figure 1.

Remark:

The tested "Besta" composite mineral board system achieved a weighted sound reduction index, R_w (C, C_{tr}) = 36 (0, -2).

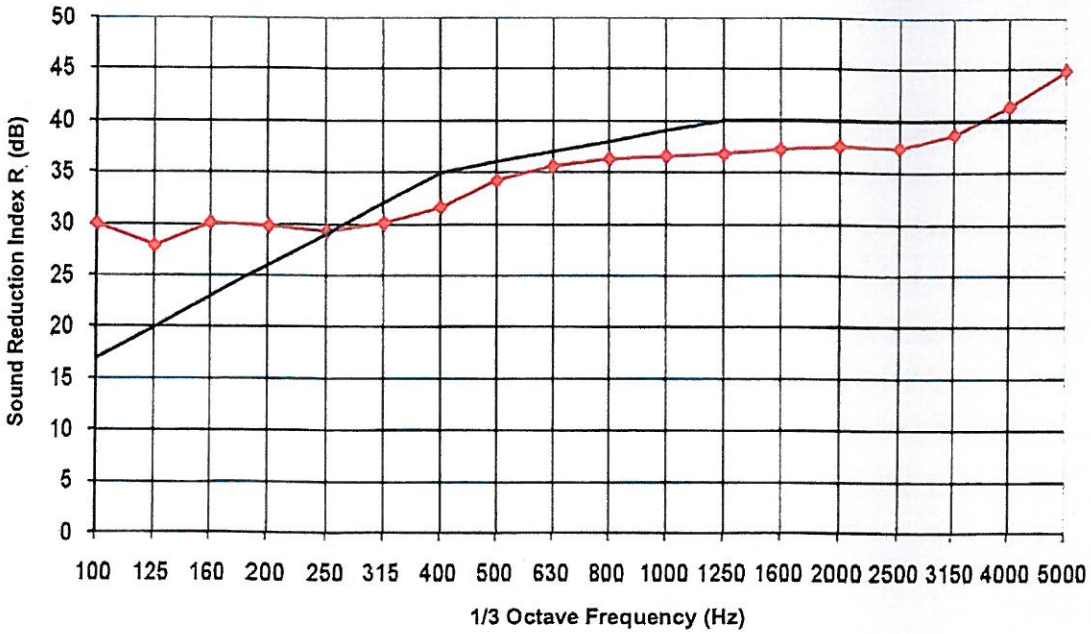
Francis Ee Min Kuen
Testing Officer

Dr Sun Qiqing
Assistant Vice President
Acoustics & Vibration
Testing Services

PSB Singapore

RESULTS: (cont'd)

Figure 1 : Sound insulation performance of "Besta" composite mineral board system



Measured Sound Reduction Index, R

Shifted reference curve, R_w = 36

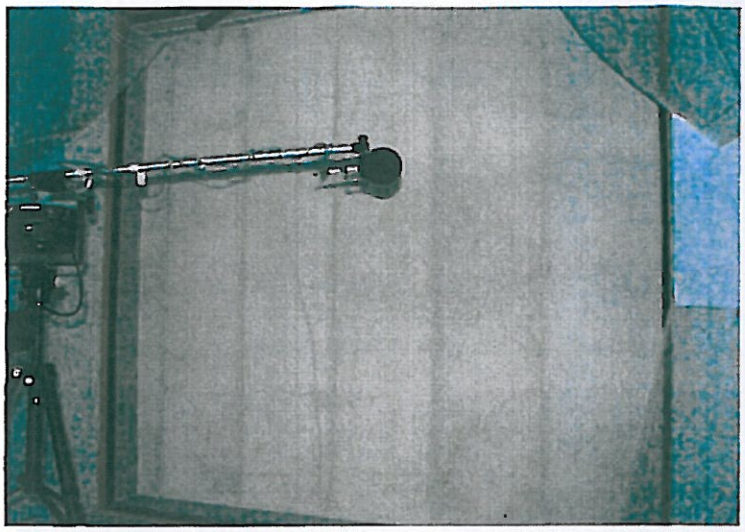


Figure 2 : "Besta" composite mineral board system facing the source room

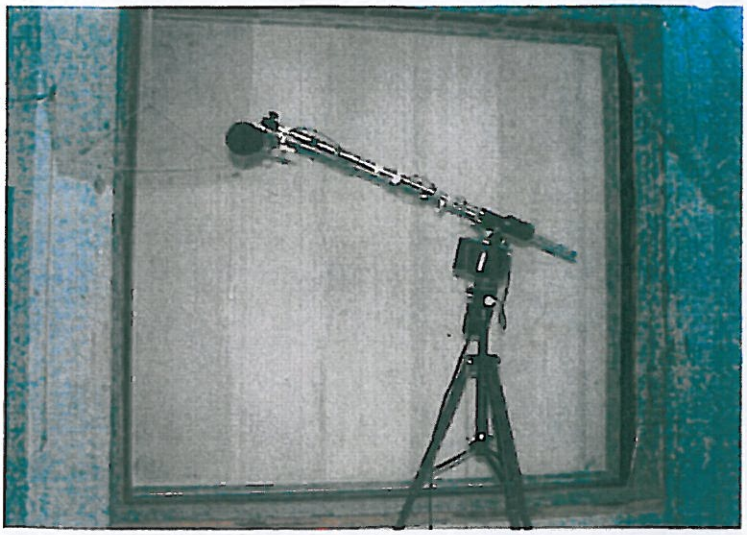


Figure 3 : "Besta" composite mineral board system facing the receiving room

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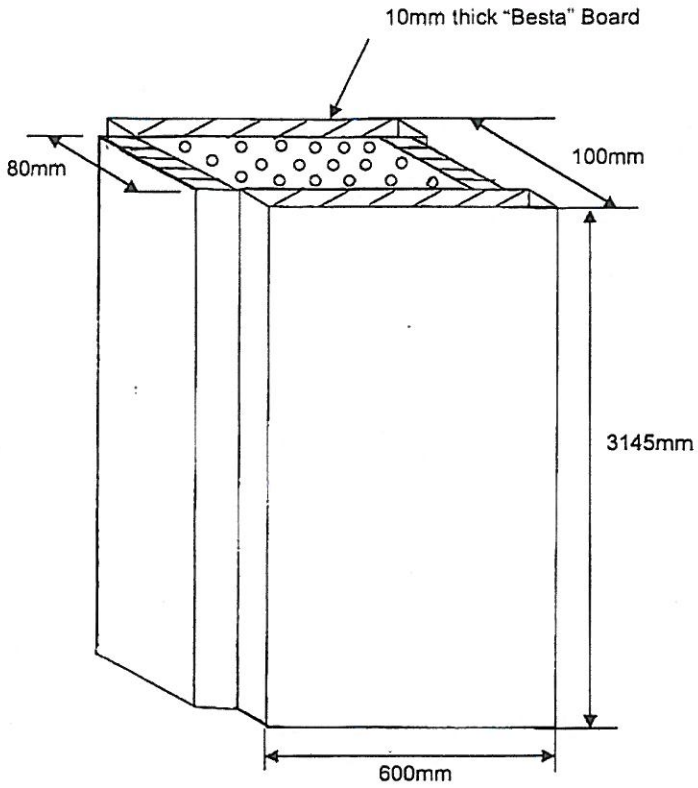

Figure 4 : "Besta" composite mineral board panel

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January 2008

d4) Laboratory Measurement of Impact Sound Insulation

Test Report No. S08MEC04781/B/EMK
dated 18 Aug 2008

PSB Singapore

Note: This report is issued subject to TÜV SÜD PSB's "Terms and Conditions Governing Technical Services". The terms and conditions governing the issue of this report are set out as attached within this report.

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SUBJECT:

Laboratory measurement of impact sound insulation of "Besta" board panel system submitted by Best Rock Building Systems Pte Ltd on 4 Aug 2008.

TESTED FOR:

Best Rock Building Systems Pte Ltd
14 Zion Road
Singapore 247732

Attn : Mr Daniel Wong

DATE OF TEST:

12 Aug 2008

DESCRIPTION OF SAMPLES:

The "Besta" board panel system was installed on the horizontal opening of the receiving room for impact sound transmission test by Best Rock Building Systems Pte Ltd.

The "Besta" board panel system was consisted of 6 pieces of board panel. Each board panel comprised of 1 piece of 12mm thick "Besta" board and 1 piece 18mm thick "Besta" board bonded together with contact adhesive (dunlop glue).

The joining of panel-to-panel and the perimeter seal of the composite mineral board system was used by silicone sealant.

The technical drawing of the board panel system was shown in Figure 4.

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Regional Head Office:
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3 Science Park Drive, #04-01/05
The Franklin, Singapore 118223
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PSB Singapore

METHOD OF TEST:

The test was conducted in accordance with ISO 140 – 6 : 1998 "Laboratory measurements of Impact Sound Insulation of floors".

Area of test specimen: 10.24m^2
Air temperature in receiving room: 26°C
Relative air humidity in receiving room: 68%
Receiving room volume: 84m^3
Location of the test : Acoustics Lab of TÜV SÜD PSB Pte Ltd

TEST EQUIPMENT:

The following instruments were used for the test.

1) A dual-channel real-time frequency analyser (B&K Type 2133)
2) A tapping machine (B&K Type 3207)
3) A ½" condenser microphone with preamplifers (B&K Type 4190)
4) A sound pressure level calibrator (Norsonic Type 1251)
5) A set of rotating microphone booms (B&K Type 3923)

TEST PROCEDURES:

1) Instrumentation was set up according to ISO 140 – 6 : 1998.

2) Measurement system was calibrated using a sound level calibrator Norsonic Type 1251.

3) Background noise level for receiving room was measured.

4) Tapping machine was switched on and placed on the top surface of the roof system at 45° to the direction of the beams and maintained at constant noise level. The sound pressure level in the receiving room was ensured to be 15dB higher than the background noise level.

5) Recording time for both rotating microphone booms was set to 64s which equals to the time taken by the booms to complete two revolutions.

6) Impact sound pressure level in the receiving room was measured with a dual – channel acoustic analyser (B&K 2133), and the measurement was repeated twice.

7) Step 4 was repeated thrice at 3 different tapping positions. The 2 others position is taken from the centre location.

8) Reverberation time (RT) of the receiving room was measured from two different loudspeaker positions.

9) The mean values of the four readings for impact sound pressure level and four readings for RT values were calculated.

10) Values of normalised impact sound pressure level and sound absorption area were determined for each 1/3 octave frequency band from 100Hz to 5kHz based on the mean values of step 9.

11) Weighted normalised impact sound pressure level was calculated based on the values of step 10. The shifted reference curve, L_n ,is shown figure 1.

PSB Singapore

RESULTS:

Values of normalised impact sound pressure level (L_n) of the tested sample were tabulated in Table 1.

Table 1 : Measured values of R and values of the shifted reference curve for $L_{n,w}$ - 86dB

1/3 Octave Frequency Band (Hz)	Normalised Impact Sound Pressure Level, L_n (dB)	Weighted Normalised Impact Sound Pressure Level, $L_{n,w}$ = 86(dB)	Deficiency
100	78	88	0
125	77	88	0
160	78	88	0
200	79	88	0
250	80	88	0
315	81	88	0
400	83	87	0
500	82	86	0
630	81	85	0
800	81	84	0
1000	79	83	0
1250	79	80	0
1600	80	77	3
2000	81	74	7
2500	81	71	10
3150	79	68	11
4000	75	65	10
5000	70	62	8
Total deficiency (100Hz – 3150Hz) :			31

Note: The values in Table 1 were plotted as shown in Figure 1.

Remarks:

The tested "Besta" board panel system achieved a Weighted Normalised Impact Sound Pressure Level, $L_{n,w}$ = 86 (C_1 = -9)

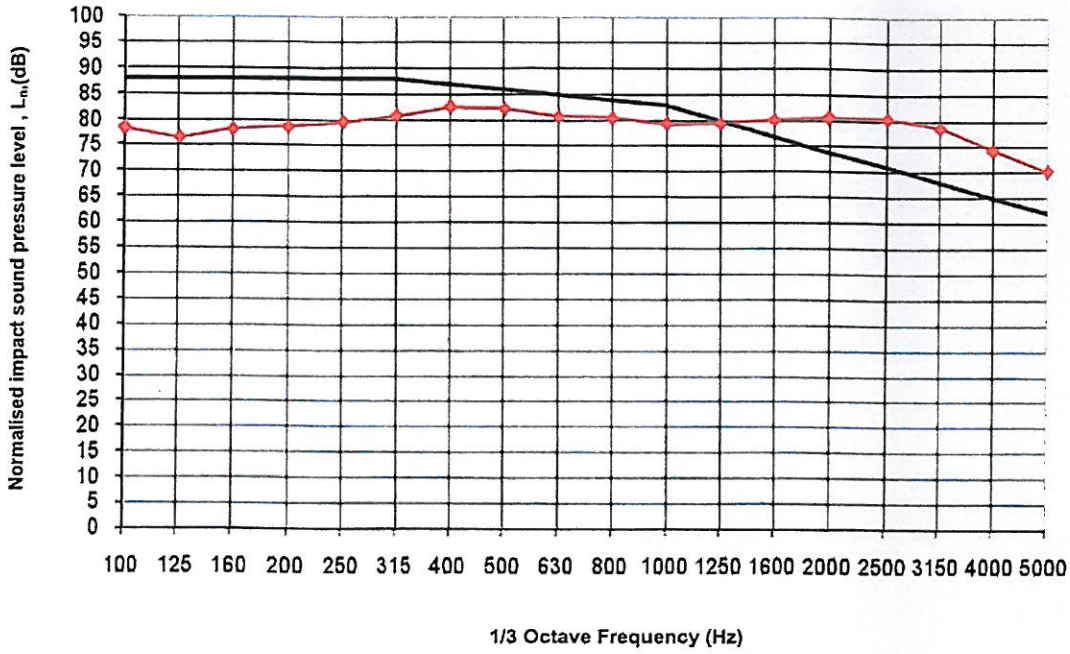
Francis Ee Min Kuen
Testing Officer

Dr Sun Qiqing
Assistant Vice President
Acoustics & Vibration
Testing Services

PSB Singapore

RESULTS: (cont'd)

Figure 1 : Impact Sound Insulation Performance of "Besta" board panel system



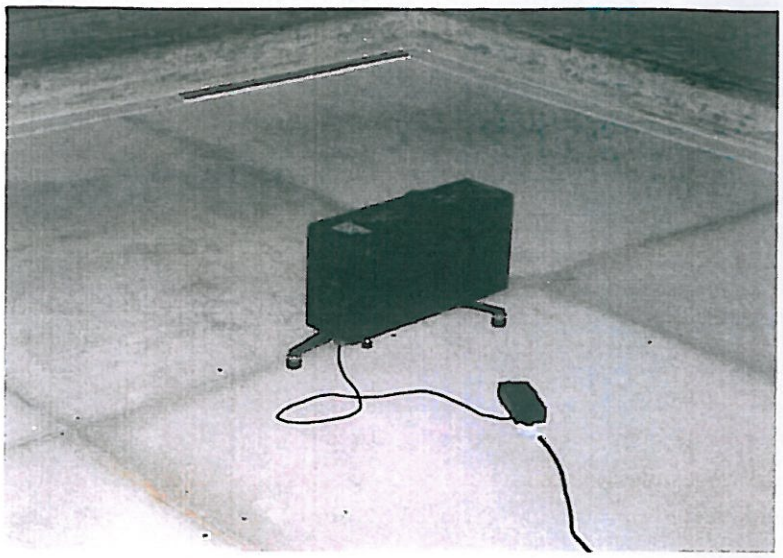
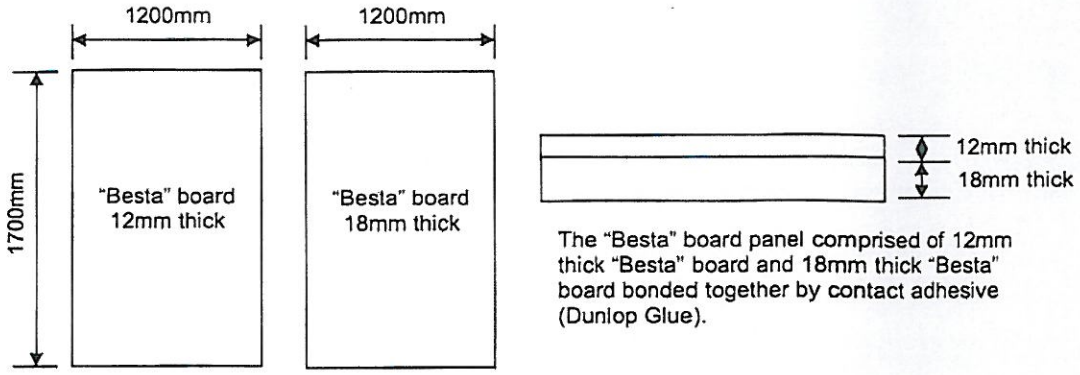


Figure 2 : Tapping machine on the "Besta" board panel system

Figure 3 : Test setup of the "Besta" board panel system (underside) facing the receiving room



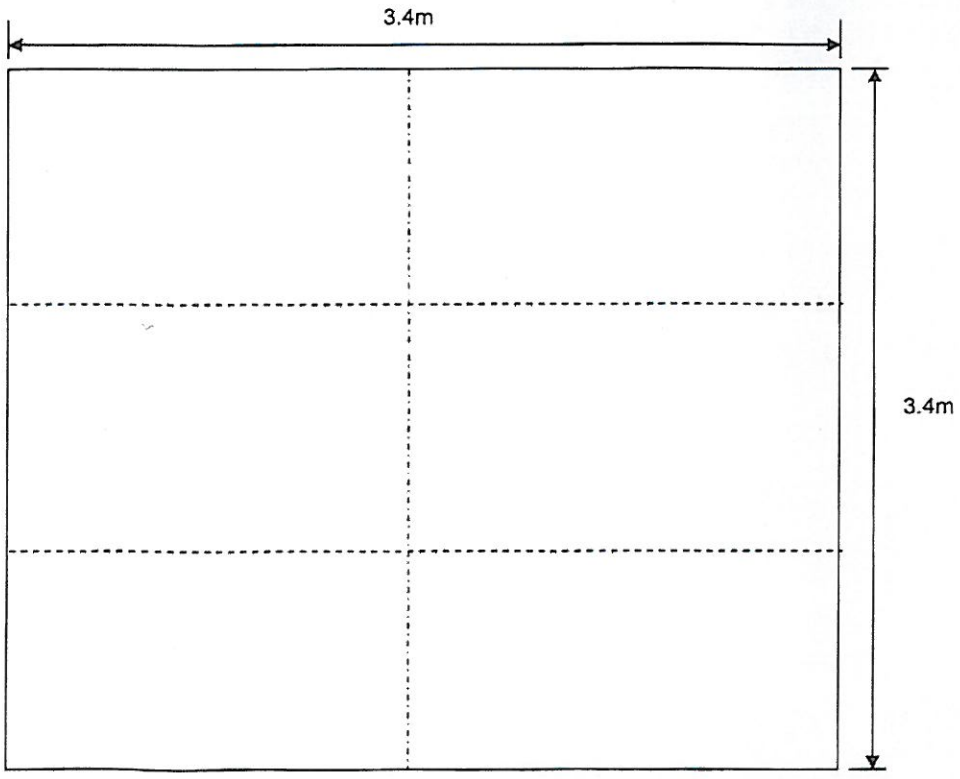


Figure 4 : Technical Drawing

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January 2008

e) Performance Testing Test Report

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Singapore 608925
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Fax: (65) 6566 7718
Website: www.setsco.com
Business Reg. No. 196900269D

TEST REPORT

(This Report is issued subject to the terms & conditions set out below)

Your Ref: -Quotation SPD/ thc2008/ dw003R dd 17th April 2008
Our Ref: SP- 2 (1) /THC

Date: 19/09/2008

Subject : Performance Testing (Strength and Robustness) on "BESTA" Magnesium Oxide (MgO) sandwich wall panel system, submitted by Best Rock Building Systems Pte Ltd on 11/07/2008.

Tested For : **M/s Best Rock Building Systems PTE LTD**
14 Zion Road
Singapore 247732
Attn: Mr. Daniel Wong

Method of Test : **Strength and Robustness to SS 492: 2001 / BS 5234 : Part 2 : 1992**

1) Determination of partition wall stiffness - Annex A
2) Surface damage by small hard body impact - Annex B
3) Resistance to damage by impact from a large soft body - Annex C
4) Resistance to perforation by small hard body impact - Annex D
5) Resistance to structural damage by impact from a large soft body - Annex E
6) Effects of door slamming - Annex F
7) Resistance to crowd pressure - Annex G
8) Lightweight anchorage pull-out - Annex H
9) Lightweight anchorage pull-down - Annex J
10) Heavyweight anchorage (wash basin) eccentric downward loading - Annex K
11) Heavyweight anchorage (high level wall cupboard) eccentric downward loading - Annex L

Specification : SS 492: 2001 / BS 5234 : Part 2: 1992 "Specification for Performance Requirements for Strength and Robustness (Including Methods of Tests for Partition Walls)".

Description of Sample : "BESTA" Magnesium Oxide (MgO) sandwich panels, consists of 10mm board+80mm perlite infill+10mm board drywall partition system were received (see photograph 1 of Appendix C).

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Performance Test on "BESTA" MgO sandwich wall panel system to SS 492 / BS 5234 : Part 2

Results: 1) Stiffness Test - Annex A

Sample Reference	100mm sandwich MgO + Perlite + MgO wall panel							SS 492 Criteria (Max.)			
								LD	MD	HD	SD
Date of Test	11/7/2008							-	-	-	-
Temperture / R.H	33 ° C / 53 %							-	-	-	-
Applied Load (N)	0	100	200	300	400	500	0	-	-	-	-
Deflection (mm)	-	0.31	0.64	1.33	1.59	1.78	-	25	20	15	10
Residual	0.25							5	3	2	1

Remark : No damage occurred to other parts of the surface during and after the test.

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Performance Test on "BESTA" MgO sandwich wall panel system to SS 492 / BS 5234 : Part 2

Results: 2) Small Hard Body Impact Test (Surface Damage) - Annex B

Sample Reference	100 mm sandwich MgO + Perlite + MgO wall panel									
Date of Test	11/07/2008 (on Main Wall)									
Temperature / R.H at test	33°C / 55%									
Impact Energy (Nm)	3									
Test Location	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
Depth of Indentation (mm)	0.42	0.29	0.42	0.38	0.57	0.65	0.36	0.26	0.32	0.27
Impact Energy (Nm)	6									
Test Location	S11	S12	S13	S14	S15	S16	S17	S18	S19	S20
Depth of Indentation (mm)	0.51	0.41	1.13	0.32	0.69	1.07	1.43	1.32	1.32	2.43
Description of Surface Damage	Damage acceptable and can be repaired									
Impact Energy (Nm)	10									
Test Location	S21	S22	S23	S24	S25	S26	S27	S28	S29	S30
Depth of Indentation (mm)	1.67	1.72	2.18	1.43	1.85	2.10	1.77	1.79	2.84	2.79
Impact Energy (Nm)	3			6			10			
Date of Test	23/07/2008 (Wall Junction)									
Temperature / R.H at test	28°C / 73%									
Test Location (above bottom)	600mm			760mm			1370mm			
Depth of Indentation (mm)	0.53			2.11			3.20			

Remark : No damage occurred to other parts of the surface during and after the test. Criteria of SS 492 : 2001: Judgement of indent (No specific criterion is given because the impact damage will vary with different materials and forms of construction; some surface damage may be acceptable because it can easily be repaired).

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Performance Test on "BESTA" MgO sandwich wall panel system to SS 492 / BS 5234 : Part 2

Results:

3) Large Soft Body Impact Test (Damage) - Annex C

Sample Reference	100mm sandwich MgO + Perlite + MgO wall panel								
Test Location	1 (left)			2 (Right)			3 (Junction Wall)		
Date of Test	11/7/2008						23/07/2008		
Temperature / R.H at test	30°C / 65 %						28°C / 73 %		
Drop Height (mm)	41	82	204	41	82	204	41	82	204
Impact Energy (Nm)	20	40	100	20	40	100	20	40	100
Permanment Deformation (mm)	0.006	0.006	0.006	0.038	0.011	0.019	0.020	0.002	0.003

Remark : No damage occurred during and after the test. Criteria of SS 492 : 2001: 2mm maximum deformation.

Results:

4) Small Hard Body Impact Test (Perforation) - Annex D

Sample Reference	100mm sandwich MgO + Perlite + MgO wall panel									
Date of Test	11/7/2008									
Temperature / R.H at test	33°C / 55%									
Impact Energy (Nm)	**5**									
Test Location	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
Depth of Indentation (mm)	1.14	0.22	0.95	0.66	1.01	0.44	0.81	0.73	0.54	1.88
Impact Energy (Nm)	**15**									
Test Location	P11	P12	P13	P14	P15	P16	P17	P18	P19	P20
Depth of Indentation (mm)	4.01	2.47	2.63	3.16	2.56	2.29	3.39	3.01	3.41	4.06
Impact Energy (Nm)	**30**									
Test Location	P21	P22	P23	P24	P25	P26	P27	P28	P29	P30
Depth of Indentation (mm)	3.99	3.96	4.88	5.63	5.59	5.11	6.25	5.87	5.50	6.85
Impact Energy (Nm)	**5**			**15**			**30**			
Test Location (above bottom)	1280m			1200m			1040m			
Date of Test	23/07/2008									
Temperature / R.H at test	28°C / 73%									
Depth of Indentation (mm)	0.97			4.87			8.26			

Remark : No damage occurred to other parts of the surface during and after the test. Criteria of SS 492 : 2001: No perforation of facing. No requirement for this grade, see the requirement Table 7.

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Performance Test on "BESTA" MgO sandwich wall panel system to SS 492 / BS 5234 : Part 2

Results: **5) LARGE Soft Body Impact Test (Structural Damage) - Annex E**

Sample Reference	100mm sandwich MgO + Perlite + MgO wall panel			
Test Location	1		2	
Date of Test	11/07/08			
Temperature / R.H at test	30°C / 65%			
Drop Height (mm)	122	245	122	245
Impact Energy (Nm)	60	120	60	120
Number of Impacts	3	3	3	3

Remark : No damage, collapse or dislocation occurred during and after the test. Criteria of SS 492 : 2001: No collapse or dislocation.

Results: **6) Door Slamming Effects - Annex F**

Sample Reference	100mm sandwich MgO + Perlite + MgO wall panel
Date of test	14/07/2008
Temperature / R.H at test	28°C / 72 %
Number of preslam	3
Residual displacement of the door frame 5 minutes after test (mm)	0.204
Mass of test door leaf (kg)	60
Number of slams	100
Residual displacement of the door frame 5 minutes after test (mm)	0.879
Grade Achieved	SD

Remark : No surface or structural damage, detachment, loosening or dislodgment of any parts or fittings or trims during and after the test. Criteria of SS 492 : 2001: No damage and 1mm maximum displacement.

Performance Test on "BESTA" MgO sandwich wall panel system to SS 492 / BS 5234 : Part 2

Results: **7) Resistance to Crowd Pressure - Annex G**

Sample Reference	100mm sandwich MgO + Perlite + MgO wall panel		
Date of test	15/07/2008		
Temperature / R.H at test	33°C / 60 %		
Load (KN) per metre length of beam	0.75	1.5	3
Deflection (mm)	1.66	4.17	9.38
Residual deformation after released for 5 min (mm)	0.14	0.55	1.18

Remark : No collapse or damage occurred during and after the test. Criteria of SS 492 : 2001: No collapse or dangerous damage.

Results: **8) Lightweight Anchorage Pull-Out Test - Annex H**

Sample Reference	100mm sandwich MgO + Perlite + MgO wall panel
Date of test	16/07/2008
Temperature / R.H at test	33°C / 54 %
Type of Anchor	Hilti HLC Sleeve anchor (see photo 35 in Appendix C attached)
Size of Anchor	ØM6 x 60 mm long
Load (N)	100
Observations	Pull-up shim plate intact during the test. No reduction in its 20N upward force.

Remark : No damage occurred during and after the test. Pull-up shim plate was not released throughout the test. Criteria of SS 492 : 2001: Shim retained.

Performance Test on "BESTA" MgO sandwich wall panel system to SS 492 / BS 5234 : Part 2

Results: **9) Lightweight Anchorage Pull-down Test - Annex J**

Sample Reference	100mm sandwich MgO + Perlite + MgO wall panel
Date of test	16/07/2008
Temperature / R.H at test	33°C / 54 %
Type of Anchor	Hilti HLC sleeve anchor (see photo 35 in Appendix C attached)
Size of Anchor	Ø M6 x 60 mm long
Load (N)	250
Observations	Pull-up shim plate intact during the test. No reduction in its 20N upward force. Maximum displacement of pull-down test bracket is 0.26 mm.

Remark : The pull-up shim plate retained and maximum displacement less than 2mm (0.26mm) at the load of 250N. Criteria of SS 492 : 2001: Shim retained and 2 mm maximum displacement.

Results: **10) Heavyweight Anchorage (Wash Basin) Eccentric Downward Loading-Annex K**

Sample Reference		100mm sandwich MgO + Perlite + MgO wall panel				SS 492 : 2001 Performance Requirements
Type of Anchor		Hilti HLC Sleeve Anchor (see photo 35 in Appendix C attached)				-
Size of Anchor (mm)		ØM6 x 60 mm				-
Date of test		18/08/2008				-
Temperature / R.H at test		34°C / 64%				-
Deflection measuring points :		Front		Back		-
Pt.1 at 1.20m; Pt.2 at 1.75m		1	2	1	2	-
Maximum deflection (mm) at :	500 N	0.04	0.27	0.38	0.23	5 mm max.
	1000 N	0.09	0.54	0.69	0.44	20 mm max.
Residual deformation (mm)	500 N	0.02	0.16	0.15	0.10	1 mm max.
	1000 N	0.11	0.08	0.01	0.01	1 mm max.
Highest load sustained (N)		up to 1000				-

Remark : Shim plate intact but gaps between bracket and wall were noted, (see photo 25), a fine crack also found the top left anchorage point (see photo 28) after the test./dislodgment of its parts or fixings after the test.

Performance Test on "BESTA" MgO sandwich wall panel system to SS 492 / BS 5234 : Part 2

Results: **11) Heavyweight Anchorage Eccentric Downward Loading Test (High level wall Cupboard)-Annex L**

Sample Reference		100mm sandwich MgO + Perlite + MgO wall panel				SS 492 : 2001 Performance Requirements
Type of Anchor		Hilti HLC Sleeve Anchor (see photo 35 in Appendix C attached)				-
Size of Anchor (mm)		ØM6 x 60 mm				-
Date of test		17/07/2008				-
Temperature / R.H at test		29°C / 52%				-
Deflection measuring points : Pt.1 at 1.20m; Pt.2 at 1.75m		Front		Back		-
		1	2	1	2	-
Maximum deflection (mm)	2000 N	0.10	0.58	0.13	0.07	15 mm max.
Residual deformation (mm)	2000 N	0.10	0.56	0.05	0.04	1 mm max.
Highest load sustained (N)		Up to 2000				-

Remark : Criteria of SS 492 : 2001: 15 mm maximum deflection and 1 mm maximum residual deformation.

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Job No: SP -2 (1) /THC

Appendix A

Results:

Summary of Test on Strength & Robustness to SS 492 : 2001 / BS 5234 : Part 2 : 1992

(Details of partition wall specimen and test reports are attached)

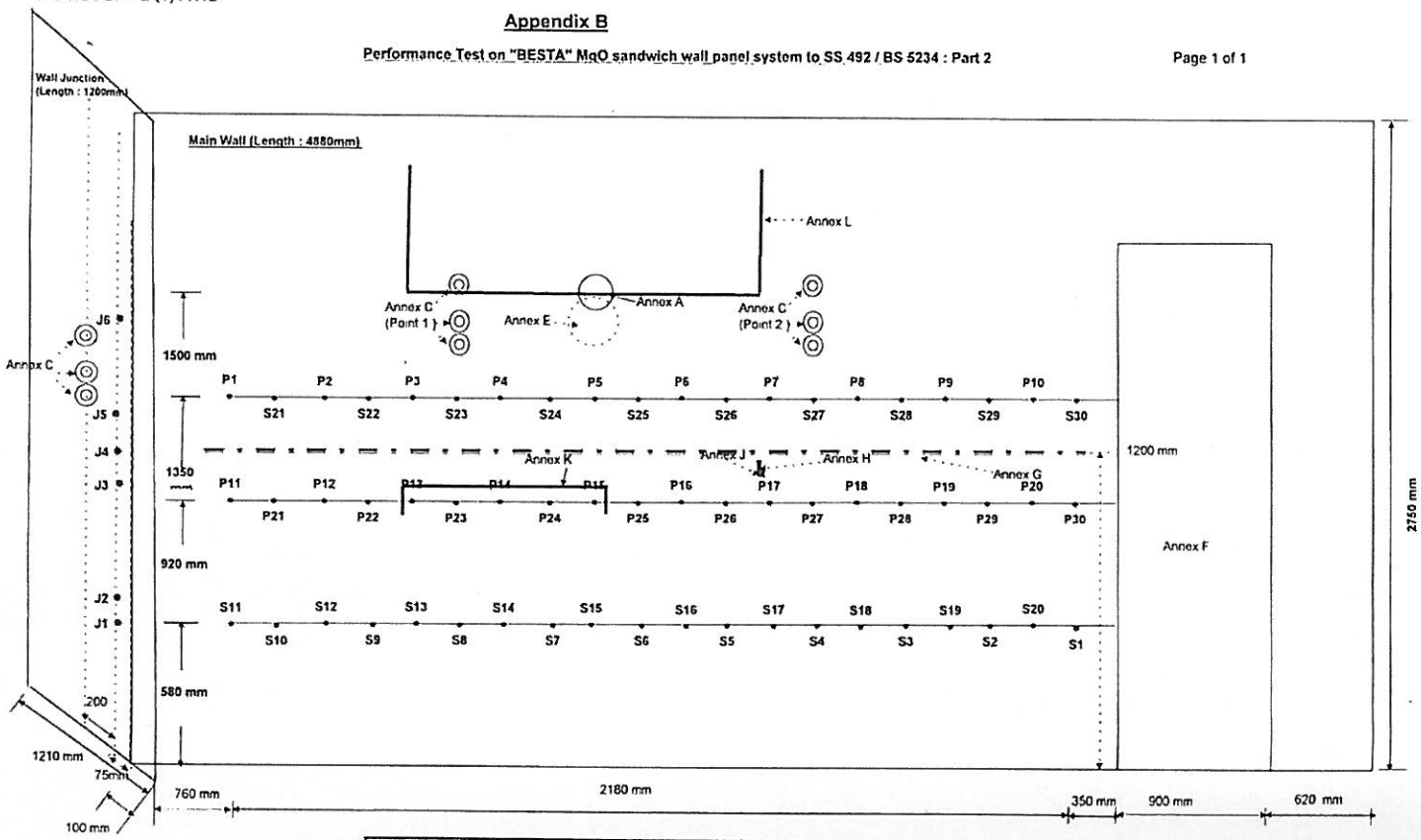
TESTS FOR GRADE COMPLIANCE	"BESTA" MgO board sandwich wall panel (10mm board + 80mm perlite + 10mm board) system			
Requirement tested	Grade Performance Achieved : Pass / Fail			
	LD	MD	HD	SD
Stiffness (Annex A)	-	-	-	Pass
Surface Damage by Small Hard Body Impact (Annex B) :-	-	-	-	
Straight Partition	-	-	-	Tested*
Right-angle Junction	-	-	-	Tested*
Resistance to Damage by Large Soft Body Impact (Annex C) :-	-	-	-	
Straight Partition	-	-	-	Pass
Right-angle Junction	-	-	-	Pass
Perforation by Small Hard Body Impact (Annex D) :-	-	-	-	
Straight Partition	-	-	-	Pass
Right-angle Junction	-	-	-	Pass
Resistance to Structural Damage by Large Soft Body Impact (Annex E)	-	-	-	Pass
Door Slamming	-	-	-	Pass
Grade Achieved	**Passed SD**			
Other Tests Performed				
Resistance to Crowd Pressure (Annex G)	**Up to 3.0 KN / m**			
Lightweight Anchorage - Pull-out (Annex H)	**Pass**			
Lightweight Anchorage - Pull-down (Annex J)	**Pass**			
Heavyweight Anchorage - Wash Basin (Annex K)	**Up to 1000N**			
Heavyweight Anchorage - Wall Cupboard (Annex L)	**2000N**			

Note : * See test report to ascertain if surface damage is acceptable.

Job No : SP - 2 (1) /THC

Appendix B

Performance Test on "BESTA" MgO sandwich wall panel system to SS 492 / BS 5234 : Part 2



Noted. Drawing not to scale

Impact Testing Point	Impact Energy (N m)	Angle of Swing (°)
S1 to S10 & J1	3	33 6
P1 to P10 & J5	5	44 2
S11 TO S20 & J2	6	48 2
S21 TO S30 & J6	10	63 6
P11 to P20 & J4	15	80 4
P21 TO P30 & J3	30	131 8

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Appendix C

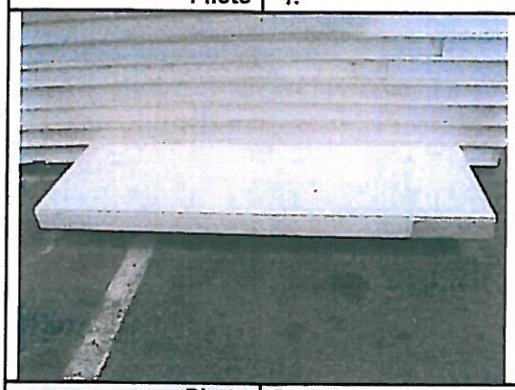
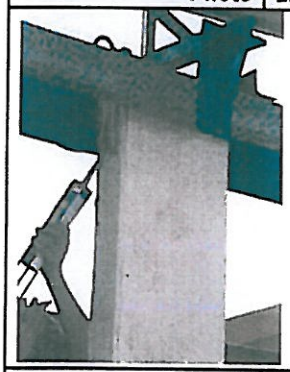
Photo 1.	
	Typical sample of "BESTA" MgO sandwich perlite wall panels of 100mm overall thickness, were received on 11/07/2008.
Photo 2.	
	Installation of the first piece "Besta" MgO sandwich perlite wall panel onto the impact and robustness test frame on 30/07/2008. "Bostik" fireban polyurethane sealant / Construction Adhesive (320g) applied as jointing material between panels. See photo 34 in Appendix C.
Photo 3.	
	The junction wall section, made up of two (02) panels of width 600mm sandwich panels erected side-by-side.

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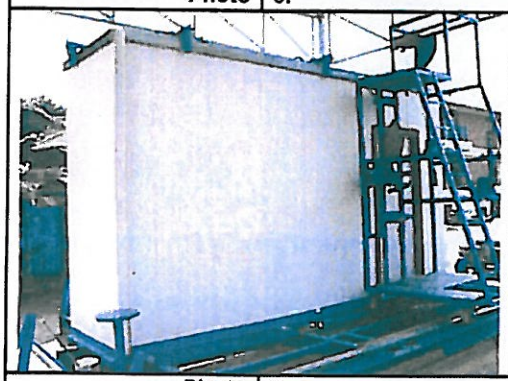
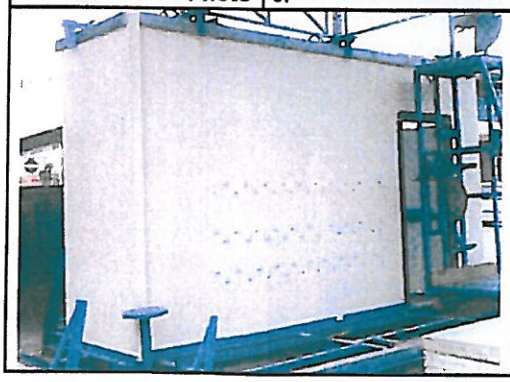
Photo 4.	
	The installation of the main wall section – in progress.
Photo 5.	
	General view of the completed "Besta" MgO sandwich perlite wall panel system under curing and before the application of emulsion paint coating.
Photo 6.	
	The second layer of off white emulsion paint coating been applied. Test locations on the surfaces of both the main and junction wall sections to undergo stiffness, surface and perforation by small hard body impact were marked.

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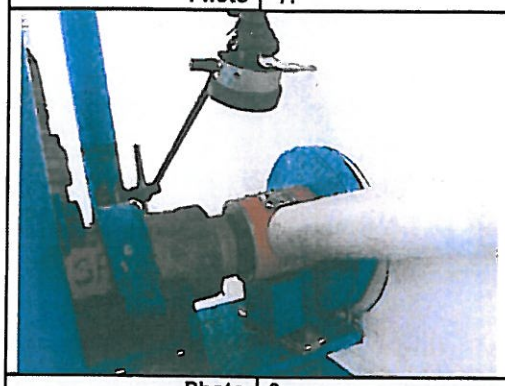
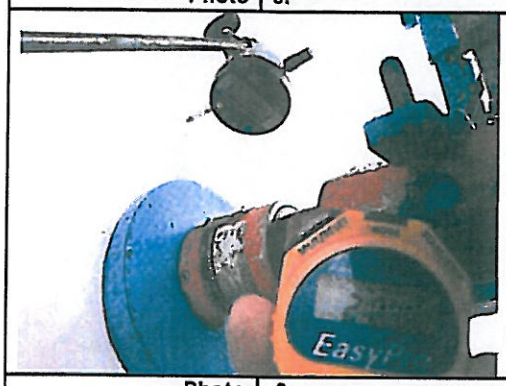
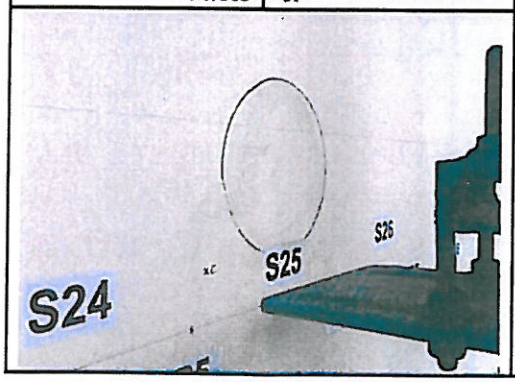
Photo 7.	
	Performance testing: Annex A: Stiffness Test on 11th July 2008.
Photo 8.	
	Performance testing : Annex A: Stiffness Test - Photo shows maximum deflection reading of 1.761 mm under 500N load after 2 minutes.
Photo 9.	
	Performance testing : Annex A: Stiffness Test - Photo shows no visible crack or other damage to the wall during and after the test.

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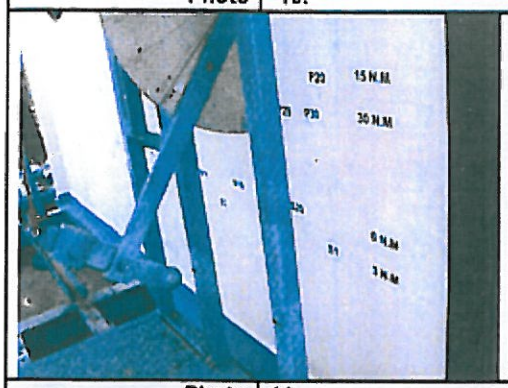
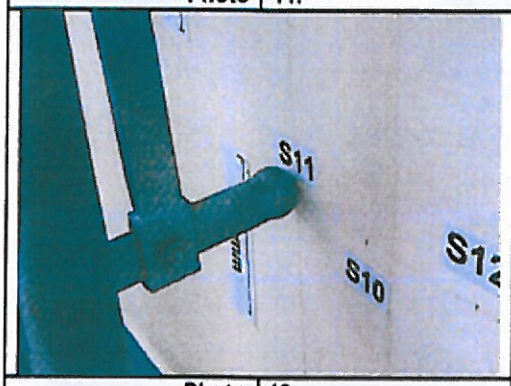
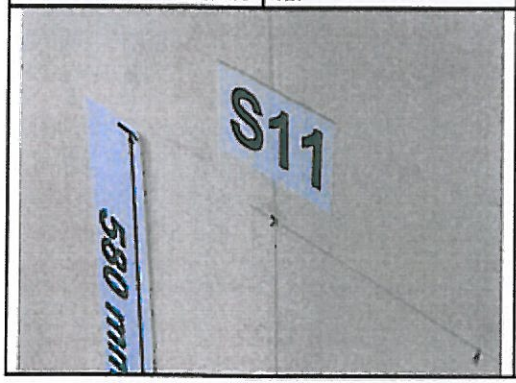
Photo 10.	
	Performance testing – Surface Damage (Annex B) and Perforation Test (Annex D) : Locations marked and ready for impact.
Photo 11.	
	Performance testing – Surface Damage (Annex B) : S11 - for surface damage test at 6Nm.
Photo 12.	
	Performance testing – Surface Damage (Annex B) : S11 - after impact test at 6Nm.

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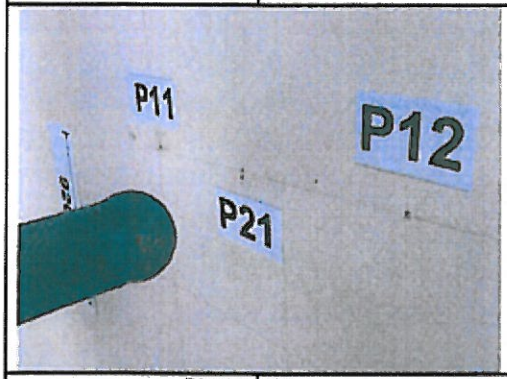
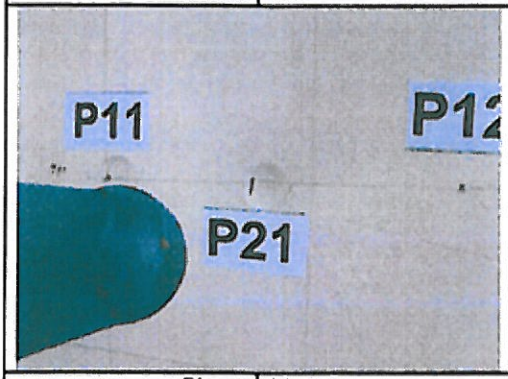
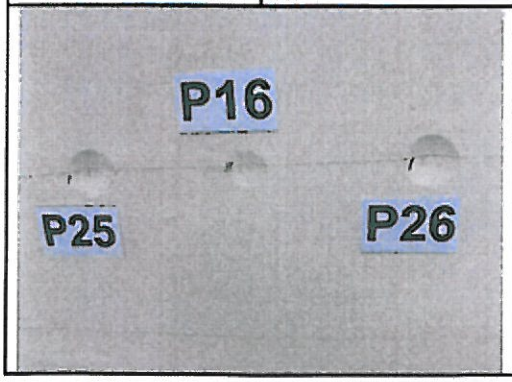
Photo 13.	
	Performance testing – Perforation Test (Annex D) : P21 – for perforation test at 30 Nm.
Photo 14.	
	Performance testing – Perforation Test (Annex D) : P21 – after perforation test at 30 Nm.
Photo 15.	
	Performance testing – Perforation Test (Annex D) : Photo shows the indentation at points P16, P25 & P26 after impacts.

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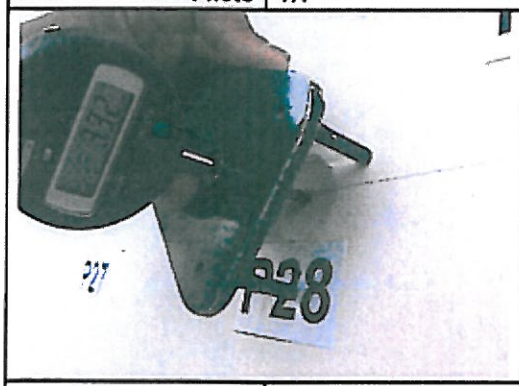
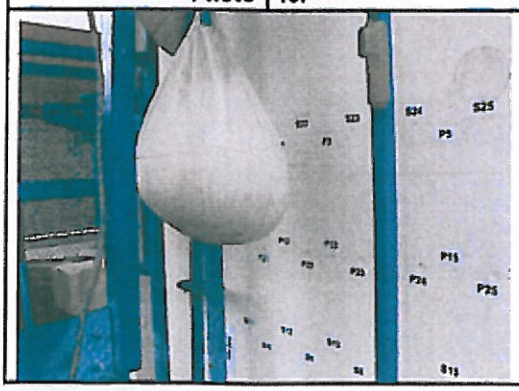
Photo 16.	
	Performance testing – Surface Damage (Annex B) and Perforation Test (Annex D) : Instrument for depth of indentation measurement.
Photo 17.	
	Performance testing – Surface Damage (Annex B) and Perforation Test (Annex D) : Measuring the depth of Indentation at point P28.
Photo 18.	
	Performance testing – Resistance to damage by impact from a large soft body (Annex C): Photo shows the setup of large soft body impact test.

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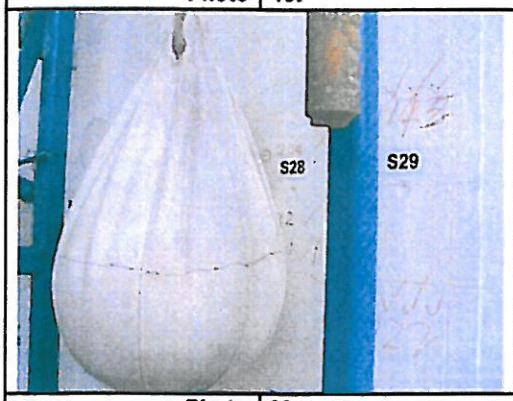
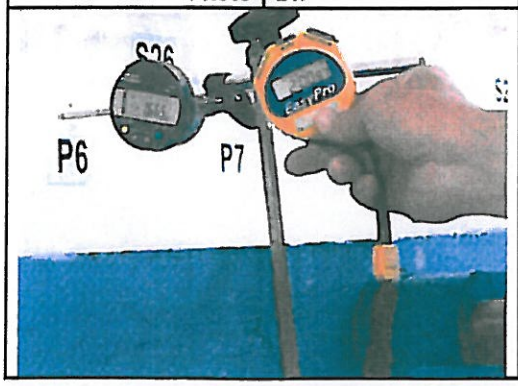
Photo 19.	
	Performance testing – Resistance to structural damage by multiple impacts from a large soft body (Annex E) : No visible crack or other damage occurred to the wall during and after the test.
Photo 20.	
	Performance testing – Effect of door slamming (Annex F) : Photo shows the setup of door leaf (60Kg) to be opened to 60° angle and slam onto the door frame by a 15Kg weight.
Photo 21.	
	Performance Testing – Resistance to crowd pressure (Annex G) : Residual deformation of -1.87 mm after the 3.0 KN per meter run horizontal load was released for 5 minutes. No damage occurred.

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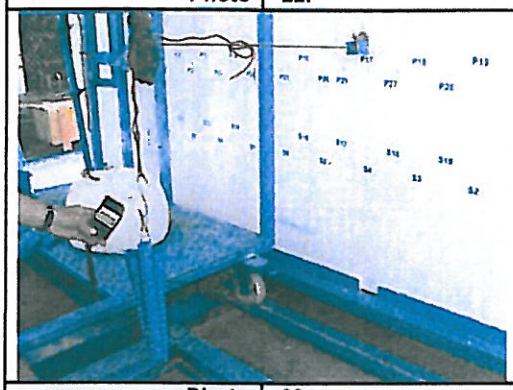
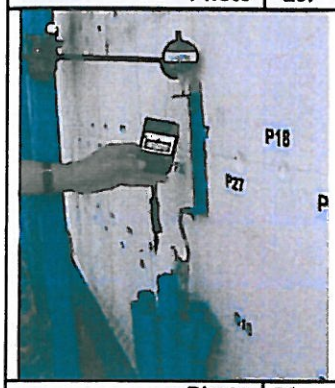
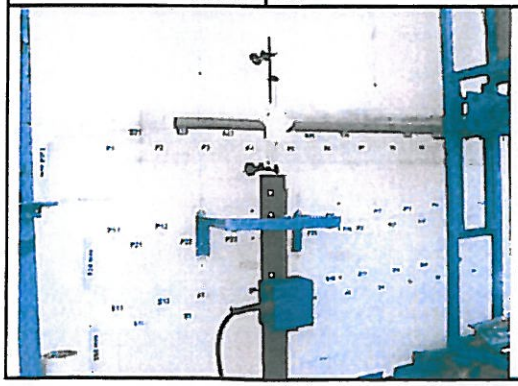
Photo 22.	
	Performance Testing – Lightweight anchorage pull-out test (Annex H) : Photo shows the setup of pull-out test in progress.
Photo 23.	
	Performance Testing – Lightweight anchorage pull-down test (Annex J) : Displacement of 0.270 mm after subjected to a pull-down load of 250N. The pull-up shim is intact. No damage occurred.
Photo 24.	
	Performance Testing – Heavyweight anchorage (wash basin) eccentric downward loading test: Annex K: Photo shows heavyweight downward loading (wash basin) test in progress.

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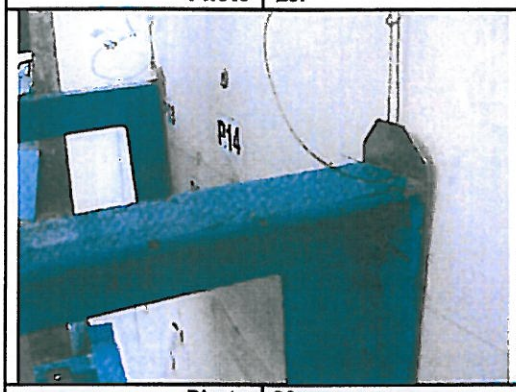
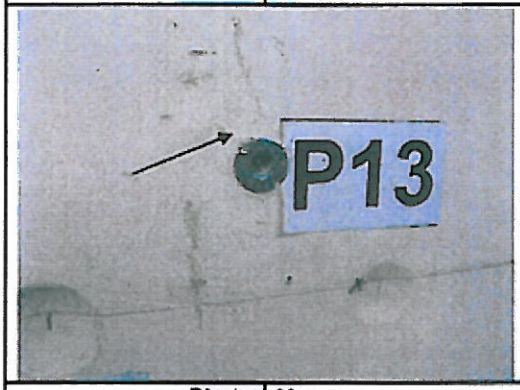
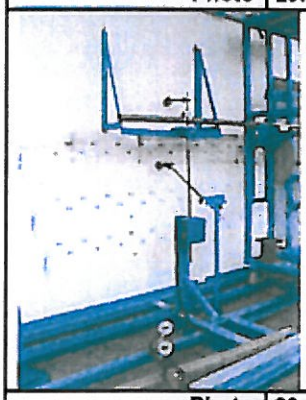
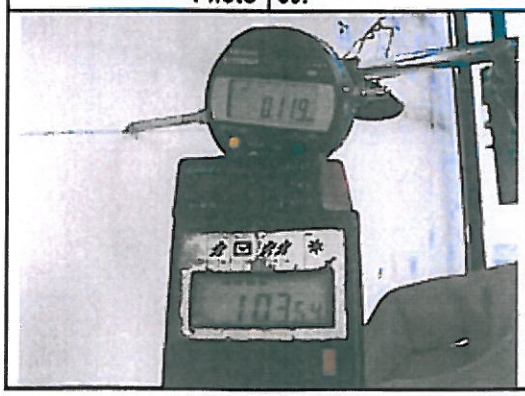
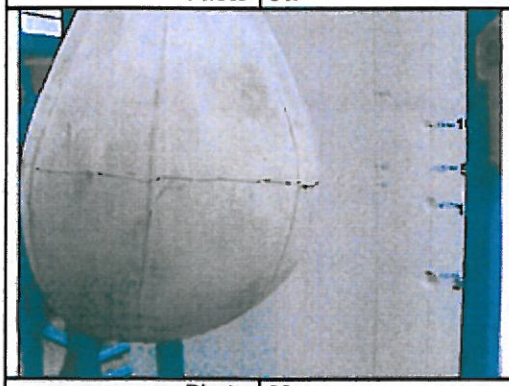
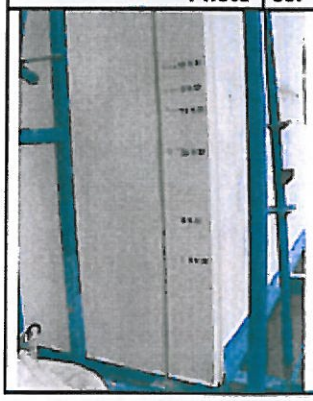
Photo 25.	
	Performance Testing – Heavyweight anchorage (wash basin) eccentric downward loading test: Annex K: Shim plate intact, gaps observed around the upper anchorage bracket and wall. A fine crack was also visible on the wall besides the upper top left end of the bracket.
Photo 26.	
	Performance Testing – Heavyweight anchorage (wash basin) eccentric downward loading test: Annex K: Gauge reading at front wall shows deflection at 1.2m height as - 0.11mm after 5 minutes.
Photo 27.	
	Performance Testing – Heavyweight anchorage (wash basin) eccentric downward loading test: Annex K: Gauge reading at front wall shows deflection at 1.75m height as - 0.077mm after 5 minutes.

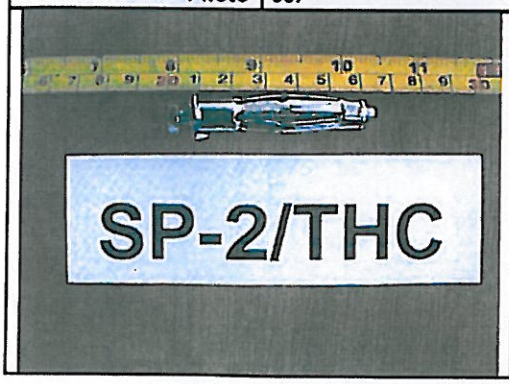
Appendix C

Photo 28.	
	Performance Testing – Heavyweight anchorage (wash basin) eccentric downward loading test: Annex K: Photo shows a fine crack on the wall around the anchorage point (top left) after test.
Photo 29.	
	Performance Testing – Heavyweight anchorage (high level wall cupboard) eccentric downward loading test: Annex L: Photo shows heavyweight downward loading (high level wall cupboard) test in progress.
Photo 30.	
	Performance Testing – Heavyweight anchorage (high level wall cupboard) eccentric downward loading test: Annex L: Gauge reading at front wall shows deflection at 1.2m height as 0.119 mm at a load of 2000N.

Appendix C

Photo 31.	
	Performance Testing: Annex C – Resistance to damage by impact from a large soft body. No damage occurred at the junction wall.
Photo 32.	
	Performance testing – Surface Damage (Annex B) and Perforation Test (Annex D) : Instrument for depth of indentation measurement at the junction wall.
Photo 33.	
	Performance testing – Surface Damage (Annex B) and Perforation Test (Annex D) : Photo shows the locations marked for small hard body impacts, i.e. surface damage and perforation at the junction wall.

Appendix C

Photo 34.	
	Bostik fireban polyurethane sealant / Construction Adhesive (320g) used as jointing material between panels.
Photo 35.	
	Type of anchorage used: Hilti HLC sleeve anchor. Size of anchors: Ø 6mm x 60 mm long used in conjunction with wash basin and high level wall cupboard tests.

6.0 CASE STUDY

Proposed Erection of 1 Block of 5-Storey Residential Apartment (Total 24 Units) with Attic, Roof Terrace, Swimming Pool and Communal Facilities on Lot/s 06199V, 06951X, 06952L and 06200T MK 26 at Rambutan Road (Geylang Planning Area), Singapore

6.0 CASE STUDY

6.1 Introduction

This case study presents the example of the application of HFW H Section product in the project. This design involves erection of one five (5) storey residential apartment at Rambutan Road (Geylang Planning Area), Singapore. The project was completed and is shown in Figure 29 and Figure 30.

6.2 Proposed Building Structural System

The structural system for this building is steel frame supported by transfered RC structure. Floor system is cast-in-site reinforced concrete floor with metal deck. External wall is Autoclave Lightweight Concrete Panel (ALCP). All partitions are light-weight partition.

The steel frame is pin-supported on RC transfer beam. Beam to column is rigid connection. All connections are using bolts connection including splice joint. Beam to house shelter is also pinned connection.

6.3 Design Criteria

The design criteria adopted are as follows:

i. Building regulation and design codes

The following codes were used for the purpose of design:

a. Building Control Regulation (1989)
b. BS 6399: Part 1: 1996 Design Loading for Buildings
c. SS CP65: Part 1: 1999 Structural Use of Concrete
d. BS 5950: Part 1: 2000 Structural Use of Steelwork in Buildings
e. CP3 : 1972 Basic Data for the Design of Building
f. CP3 : Part 2: 1972 Wind Loads
g. BS 8110: Structural use of concrete

ii. Design loading

The following superimposed loads obtained from the Fourth Schedule: The Building Control Regulation: 1989.

a. Living room/bed room

150mm Deck Floor self weight	: 3.00 kN/m^2
Finish/partitions	: 1.50 kN/m2
M&E	: 0.35kN/m^2

Ceiling	: 0.25 kN/m^2
SDL	**: 5.10 kN/m^2**
Live Load	**: 1.50 kN/m^2**

b. Toilet/kitchen

SDL	**: 5.10 kN/m^2**
Live Load	**: 2.00 kN/m^2**

c. Balcony

SDL	**: 4.00 kN/m^2**
Live Load	**: 1.50 kN/m^2**

d. RC Flat Roof/Canopy

150mm Deck Floor self weight	: 3.00 kN/m^2
Water proof	: 2.50 kN/m^2
M&E	: 0.35kN/m^2
Ceiling	: 0.25 kN/m^2
SDL	**: 6.10 kN/m^2**
Live Load	**: 1.50 kN/m^2**

iii. Material standard and specifications

The material standards and specifications for HFW H Section product are sectioned as follows:

a. Steel reinforcement

Minimum yield strength of steel reinforcement shall be as follows:

- High tensile deformed bar - f_y = 460 N/mm^2
- Mild steel plain bar - f_y = 250 N/mm^2
- Welded steel fabric - f_y = 485 N/mm^2

b. Structural steel

- Q345B (GB code)

c. Bolts

All bolts shall be Grade 10.9 high strength black bolts, unless otherwise stated.

d. Weld

Grade E50 electrodes fillet weld with design strength = 315 N/mm^2 and full penetration butt weld with design strength same as that of parent metal.

iv. Analytical Softwares

a. Excel Spreadsheet Calculations

b. Prokon

c. Staad Pro

The results of frame analysis using StaadPro are potrayed in Figure 31 - Figure 36 and discussed in Section 6.4.

v. Drawings

For this project, WASB has submitted a few drawings on architectural and structural drawing. The lists of drawings are as below:

a. Architectural drawing

- 1^{st} Storey Plan
- 2^{nd} to 4^{th} Storey Plan
- 5^{th} Storey Pland
- Attic Plan
- Roof Plan
- Elevation 1 & Elevation 3
- Elevation 2
- Elevation 4
- Section A-A
- Section B-B and Section C-C

b. Structural drawing

- Column Layout
- 3^{rd} and 4^{th} Storey Plan

- 5^{th} Storey Plan
- Attic Terrace Level
- Roof Plan
- Section a-a
- Section b-b
- Cutting at 3^{rd} and 4^{th} Storey
- Reinforcement at 3^{rd} and 4^{th} Storey
- Cutting at 5^{th} Storey
- Reinforcement at 5^{th} Storey
- Cutting at Attic Terrace Level
- Reinforcement at Attic Terrace Level
- Detail
- Section B-B

All the drawings presented in this report are structural drawing as shown in Figure 14 - Figure 28. The used of HFW H Section are shown clearly in the drawing Beam layout at 3^{rd} and 4^{th} storey plan (Figure 15), Beam layout at 5^{th} storey plan (Figure 16), Beam layout at attic storey level (Figure 17) and Beam layout at roof level (Figure 18). However, the applications of the products (i.e. ALCP and Besta Board Panel) are not indicated in the drawings.

Structural Drawings

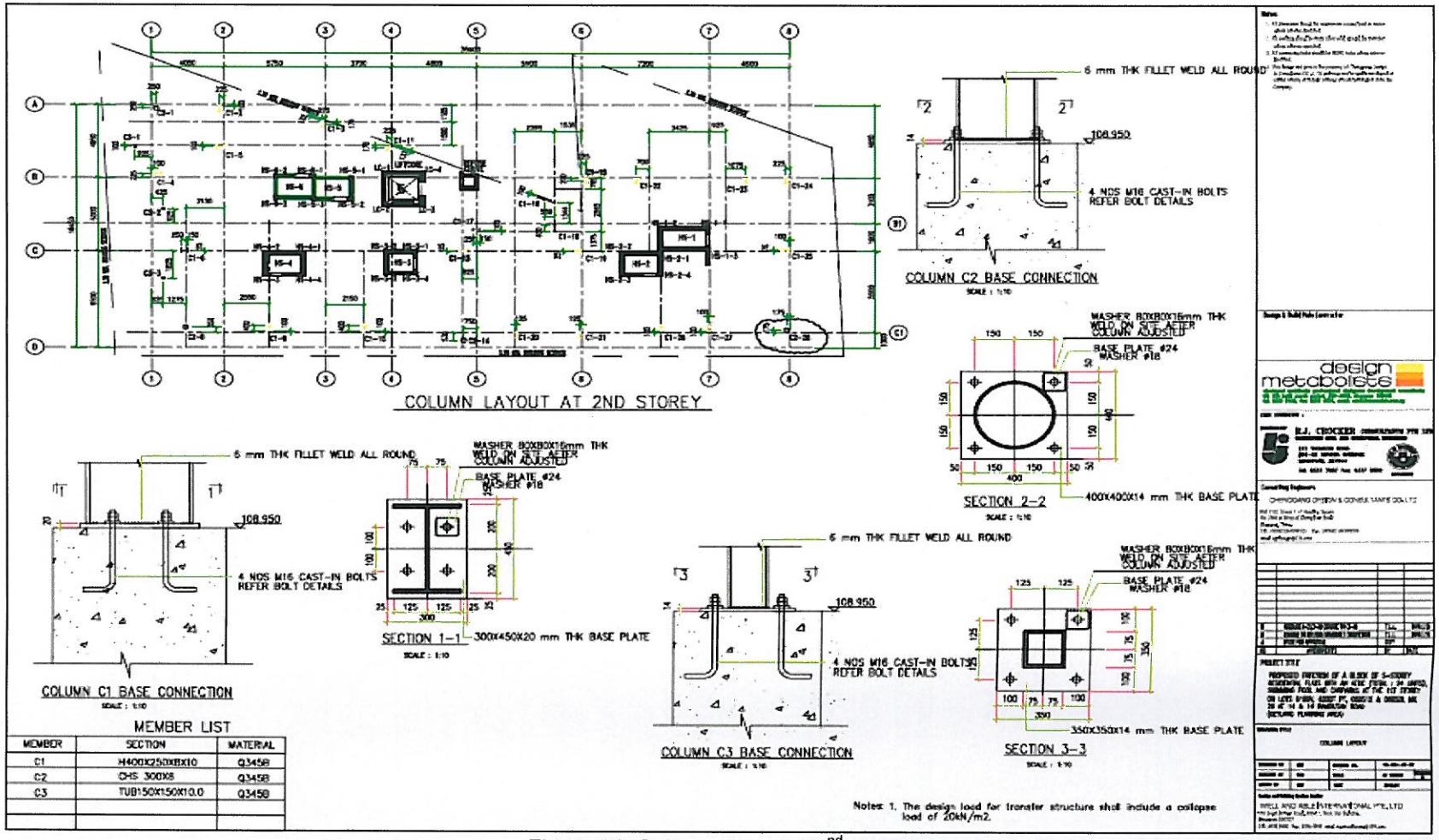


Figure 14: Column layout at 2nd storey

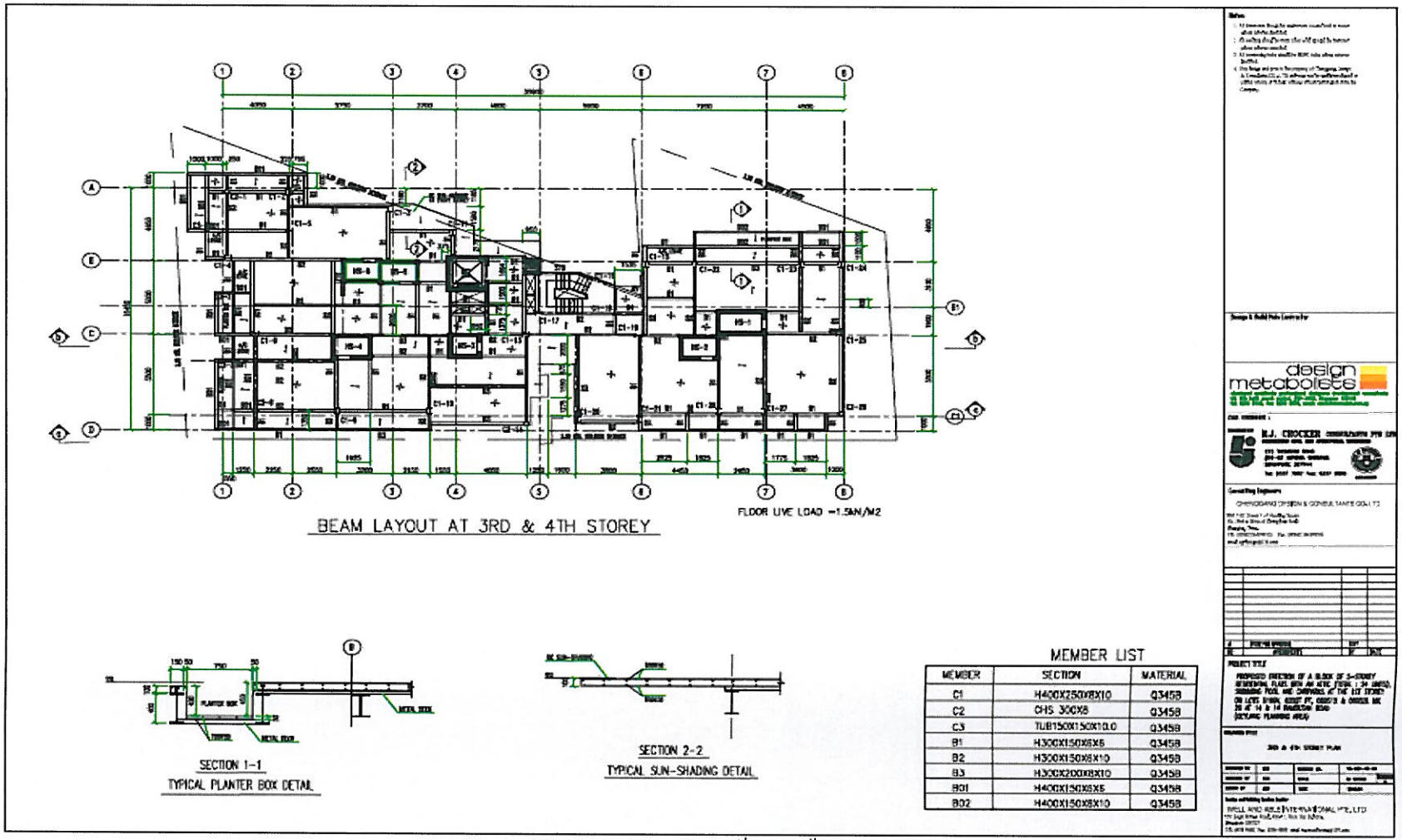


Figure 15: Beam layout at 3rd and 4th storey plan

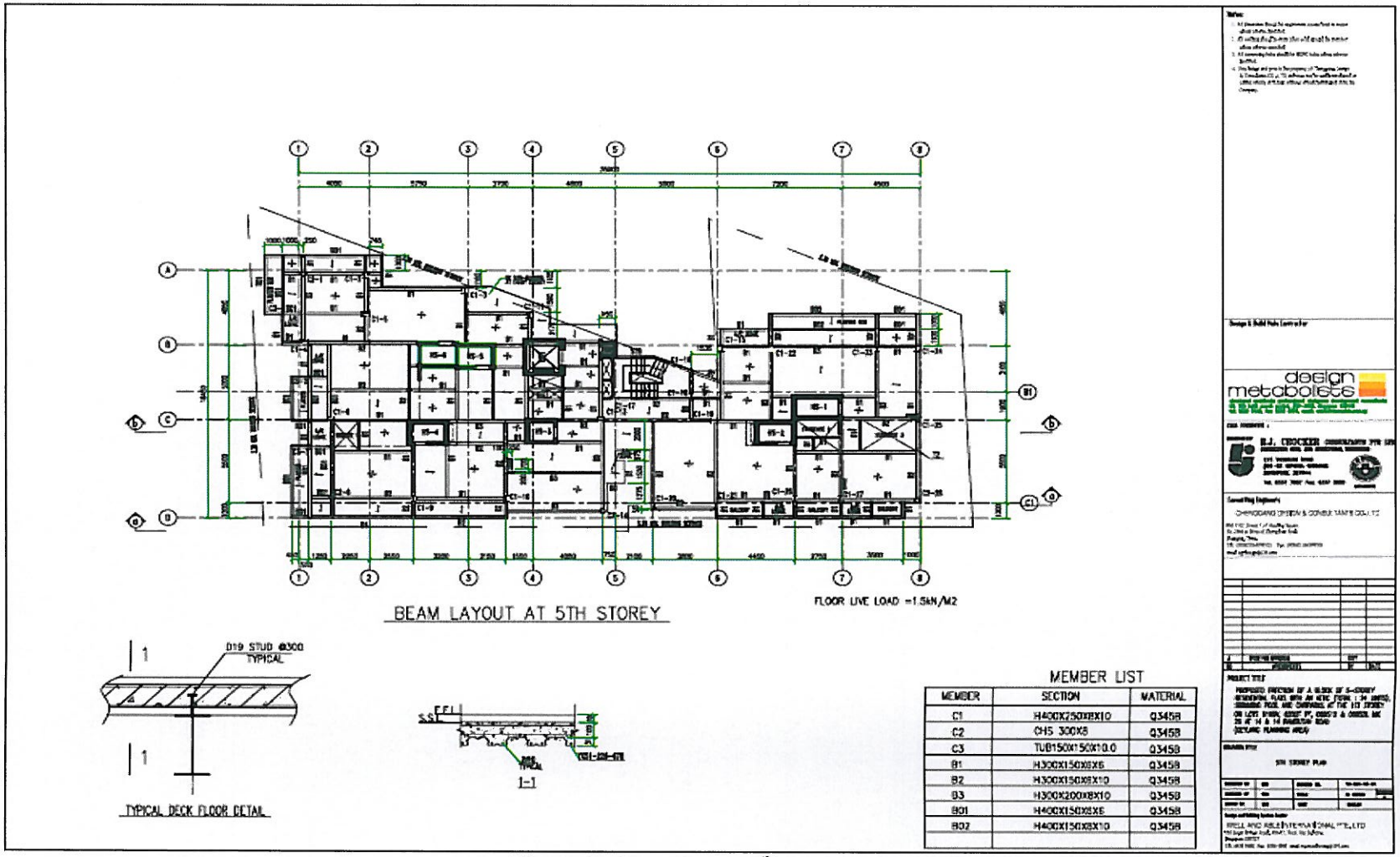
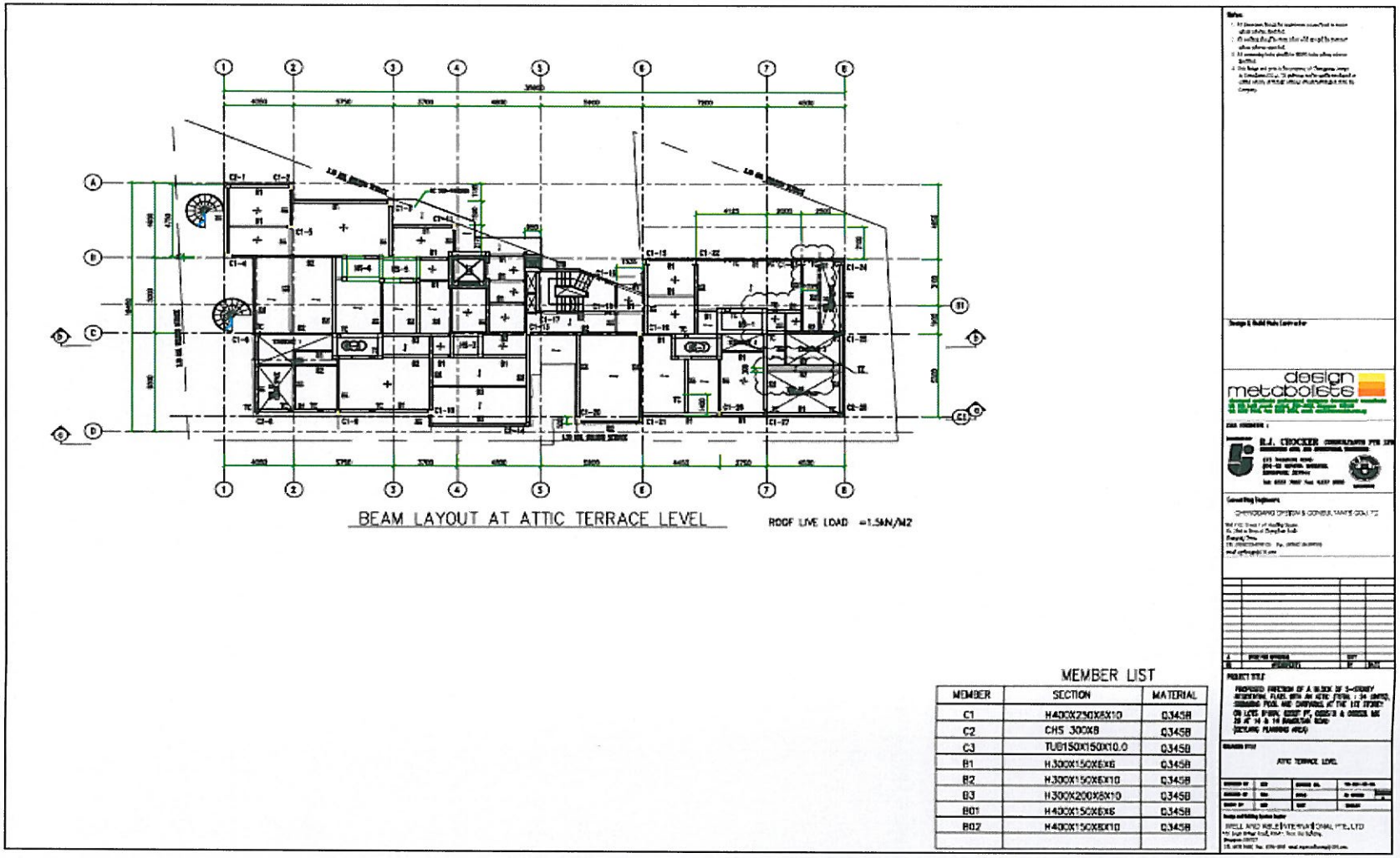


Figure 16: Beam layout 5th storey plan



MEMBER	SECTION	MATERIAL
C1	H400X230X8X10	Q345B
C2	CHS 300X8	Q345B
C3	TUB150X150X10.0	Q345B
B1	H300X150X6X6	Q345B
B2	H300X150X6X10	Q345B
B3	H300X200X8X10	Q345B
B01	H400X150X6X6	Q345B
B02	H400X150X8X10	Q345B

Figure 17: Beam layout at attic storey level

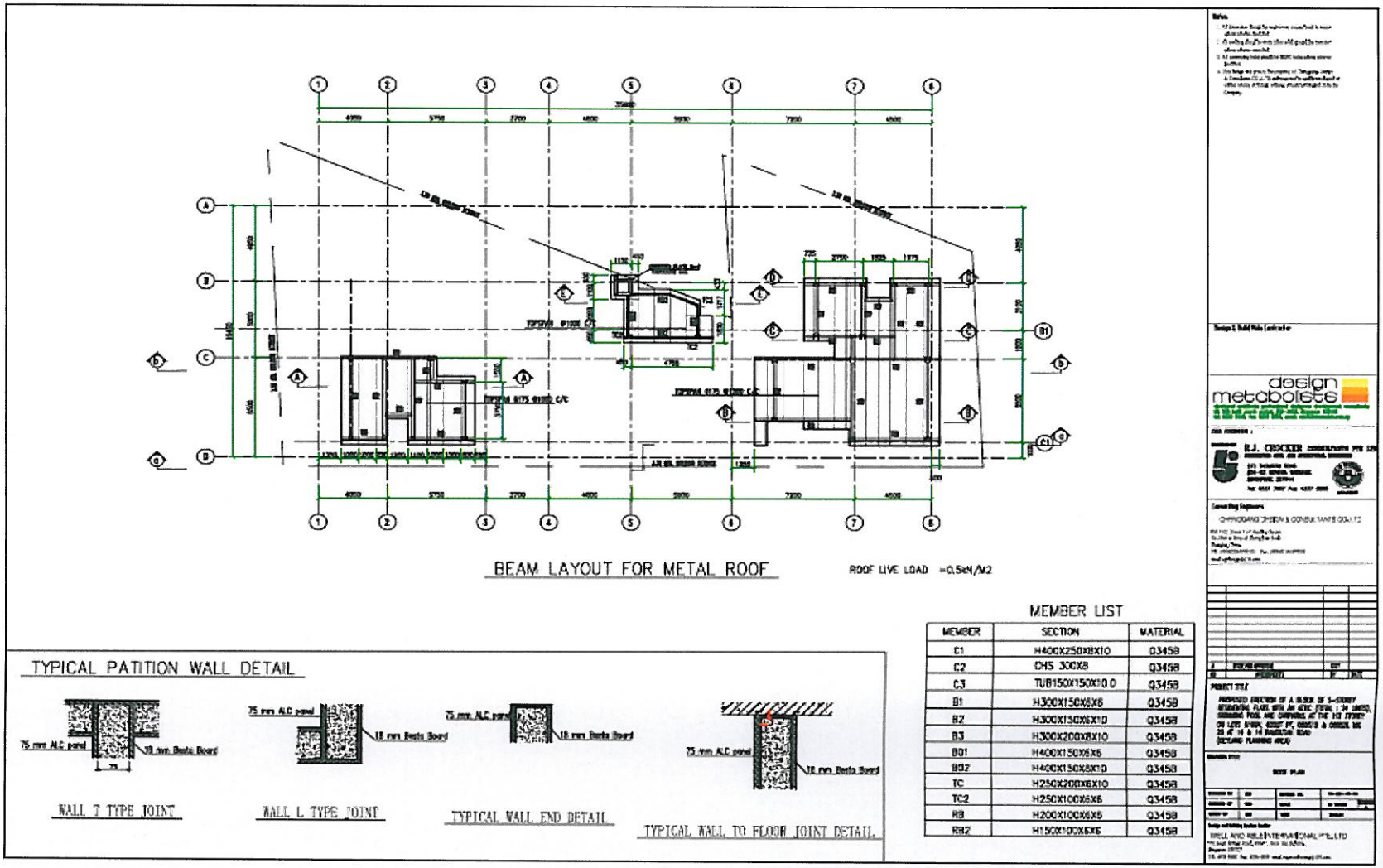


Figure 18: Beam layout at roof level

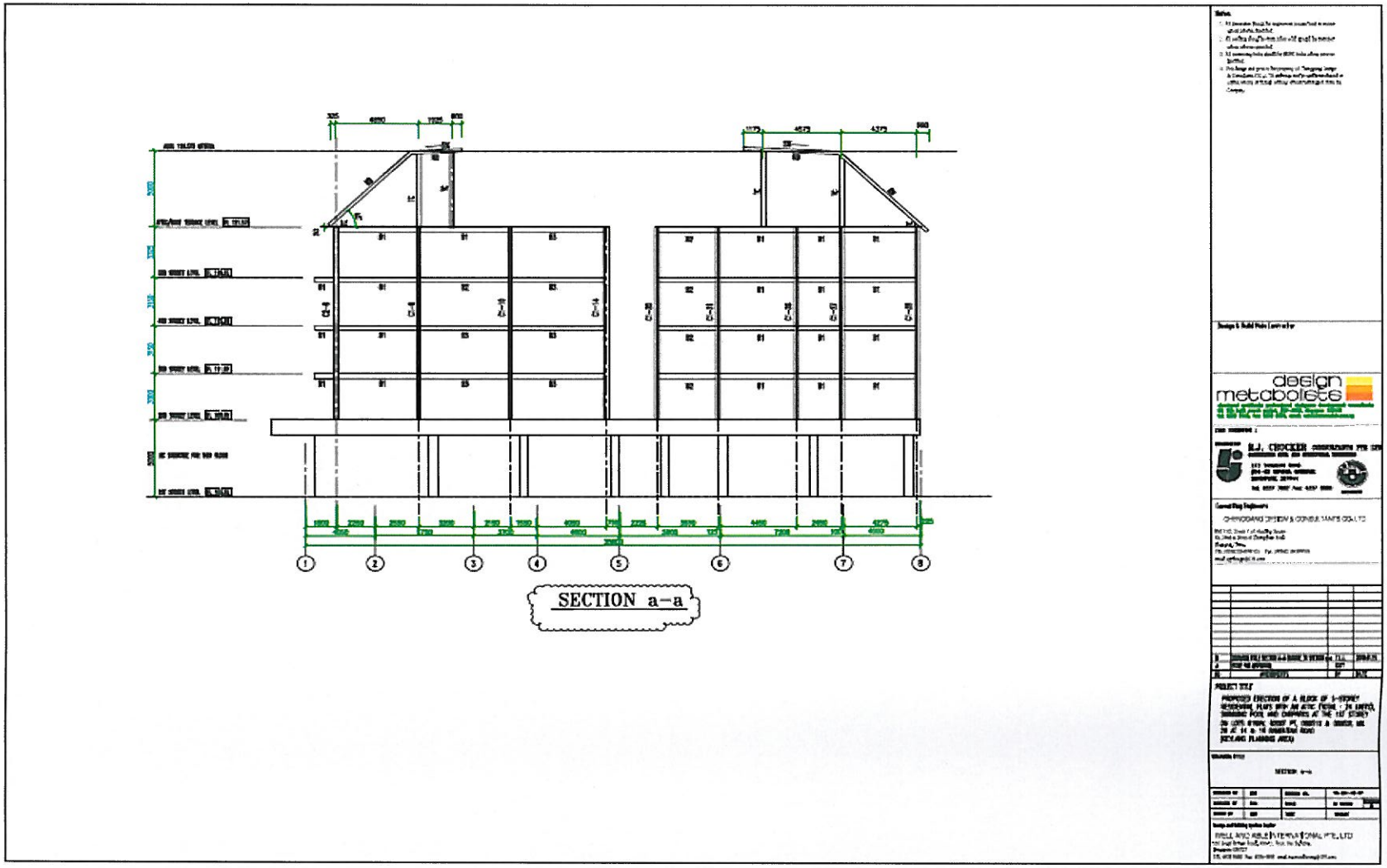


Figure 19: Section a-a

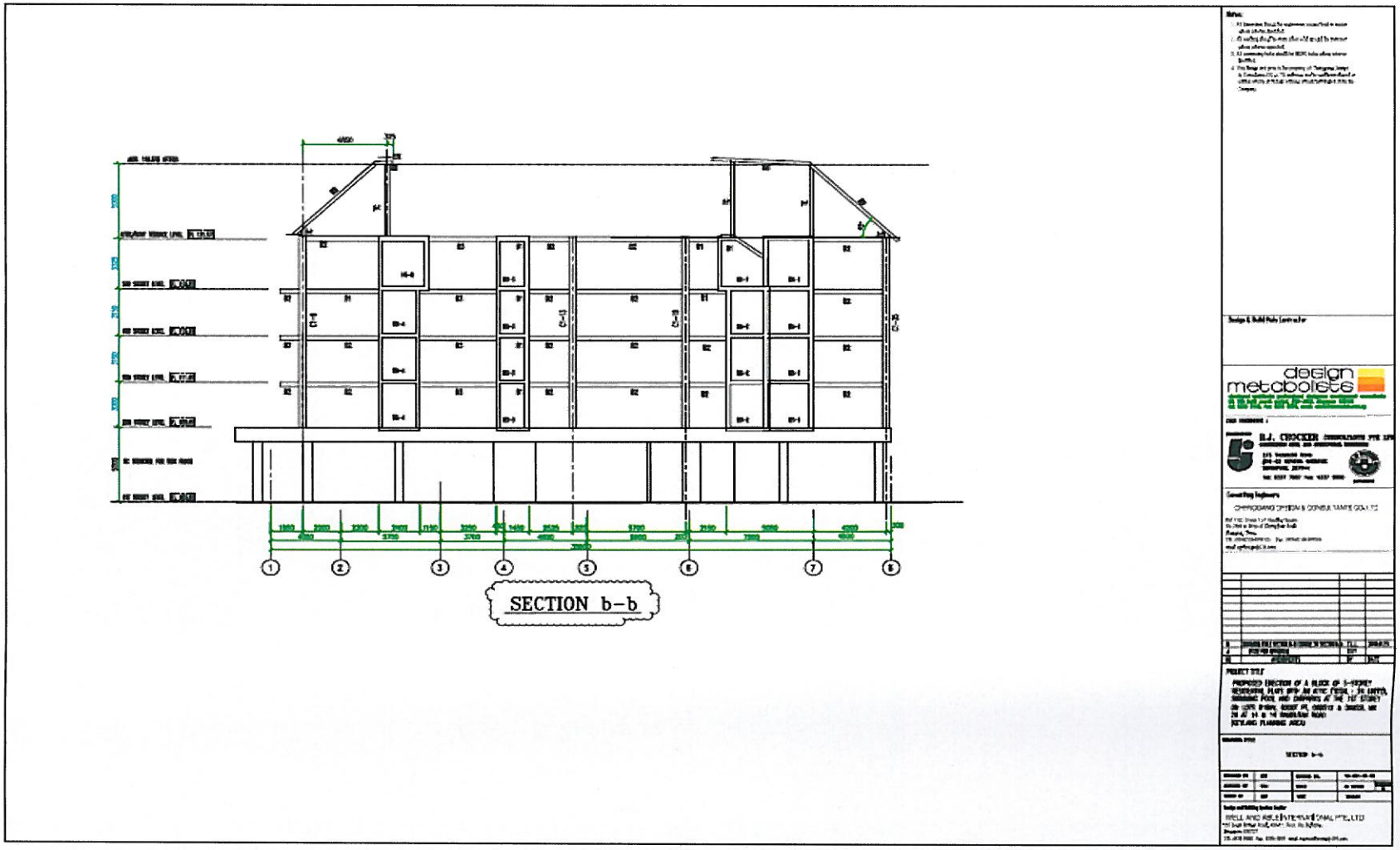


Figure 20 : Section b-b

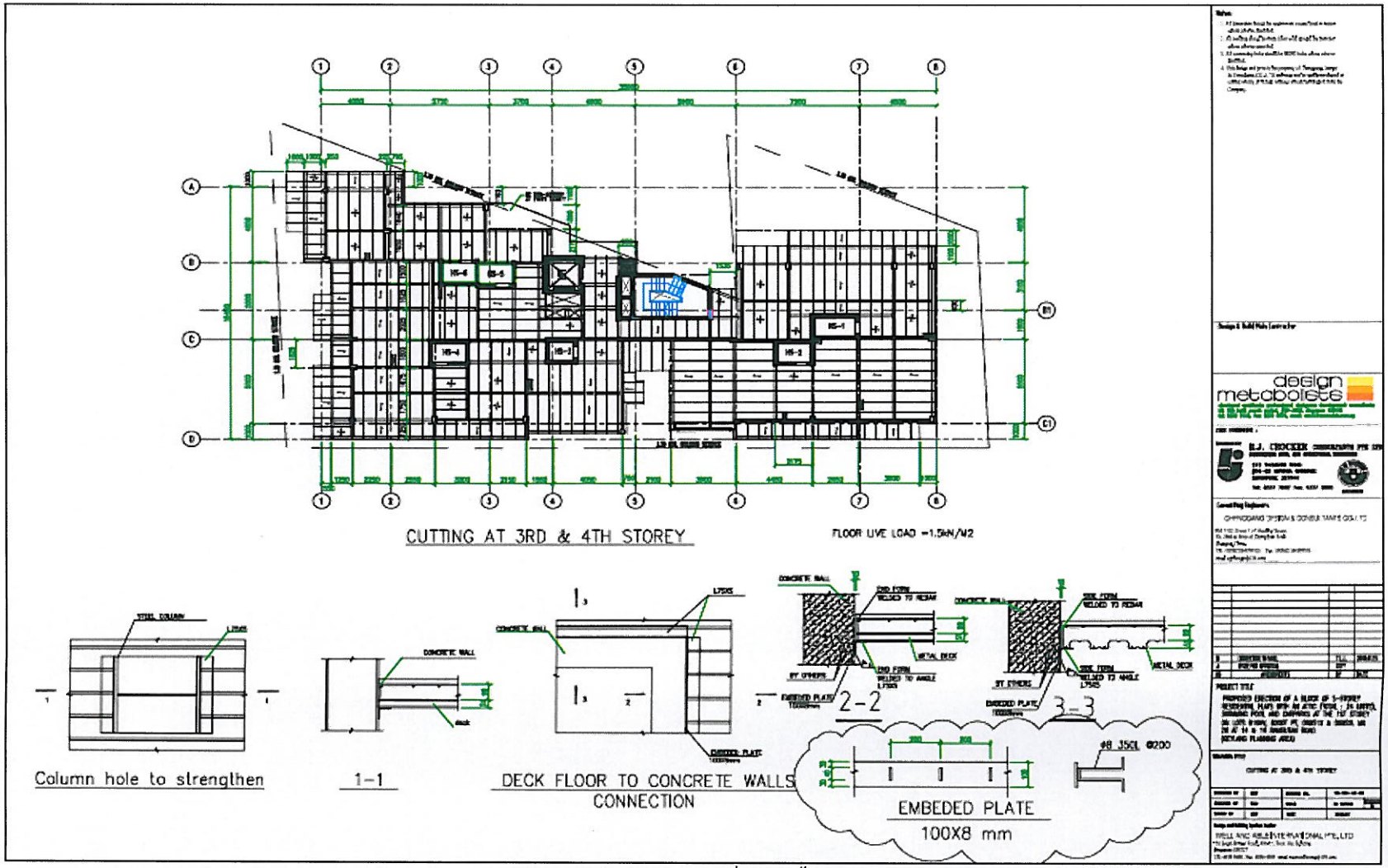


Figure 21: Cutting at 3rd and 4th storey

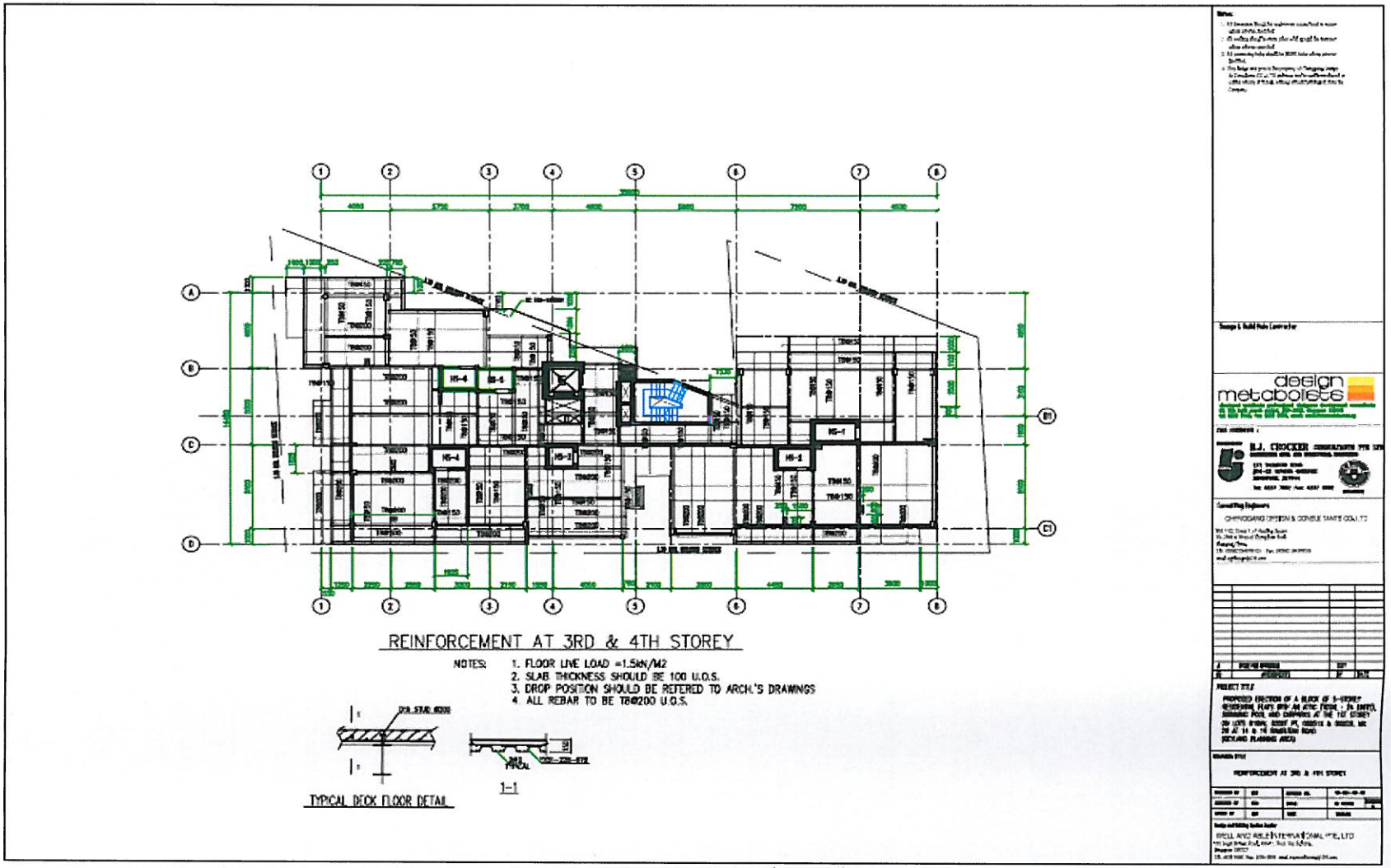


Figure 22: Reinforcement at 3rd and 4th storey

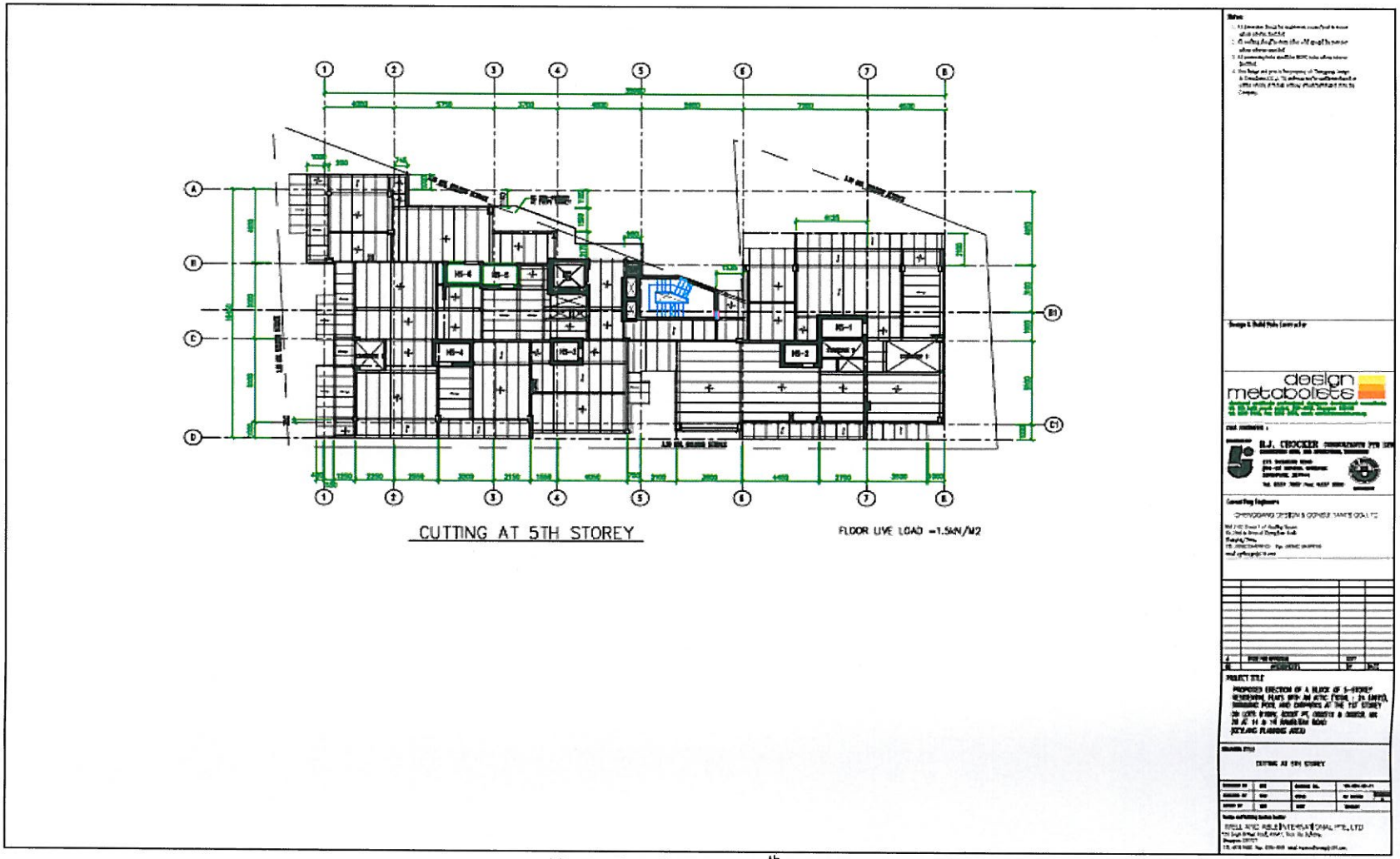


Figure 23: Cutting at 5th storey

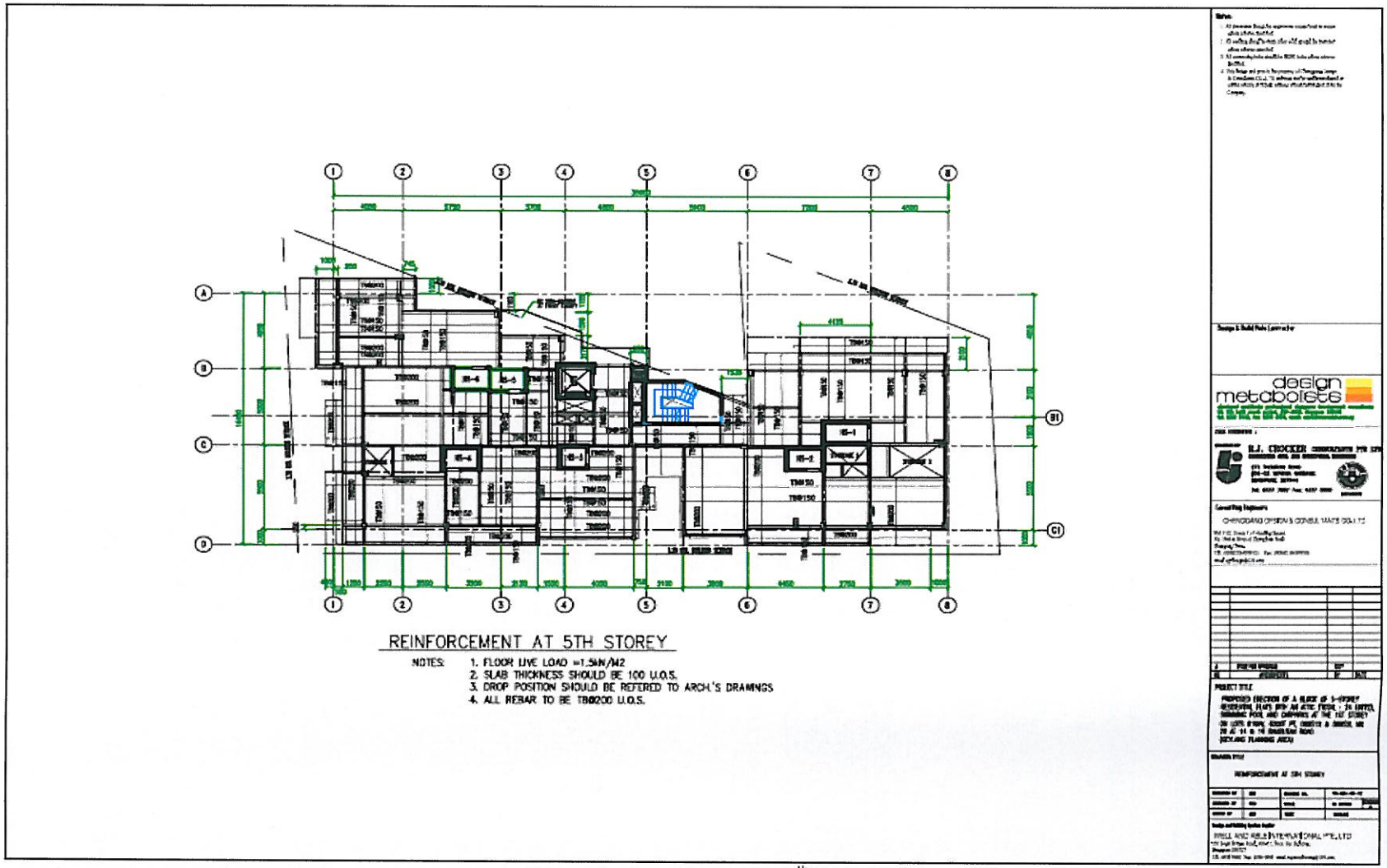


Figure 24: Reinforcement at 5th storey

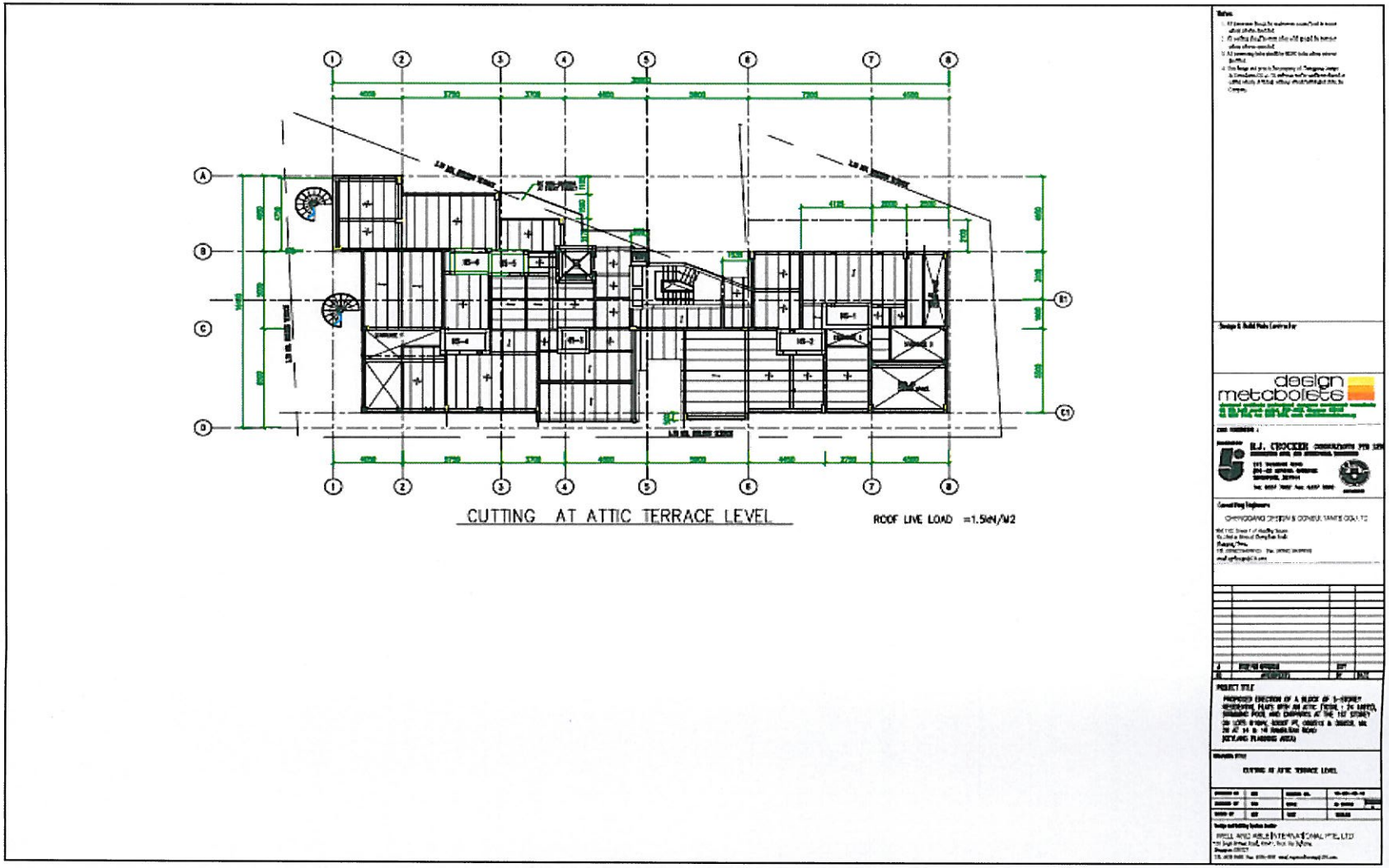


Figure 25: Cutting at attic terrace level

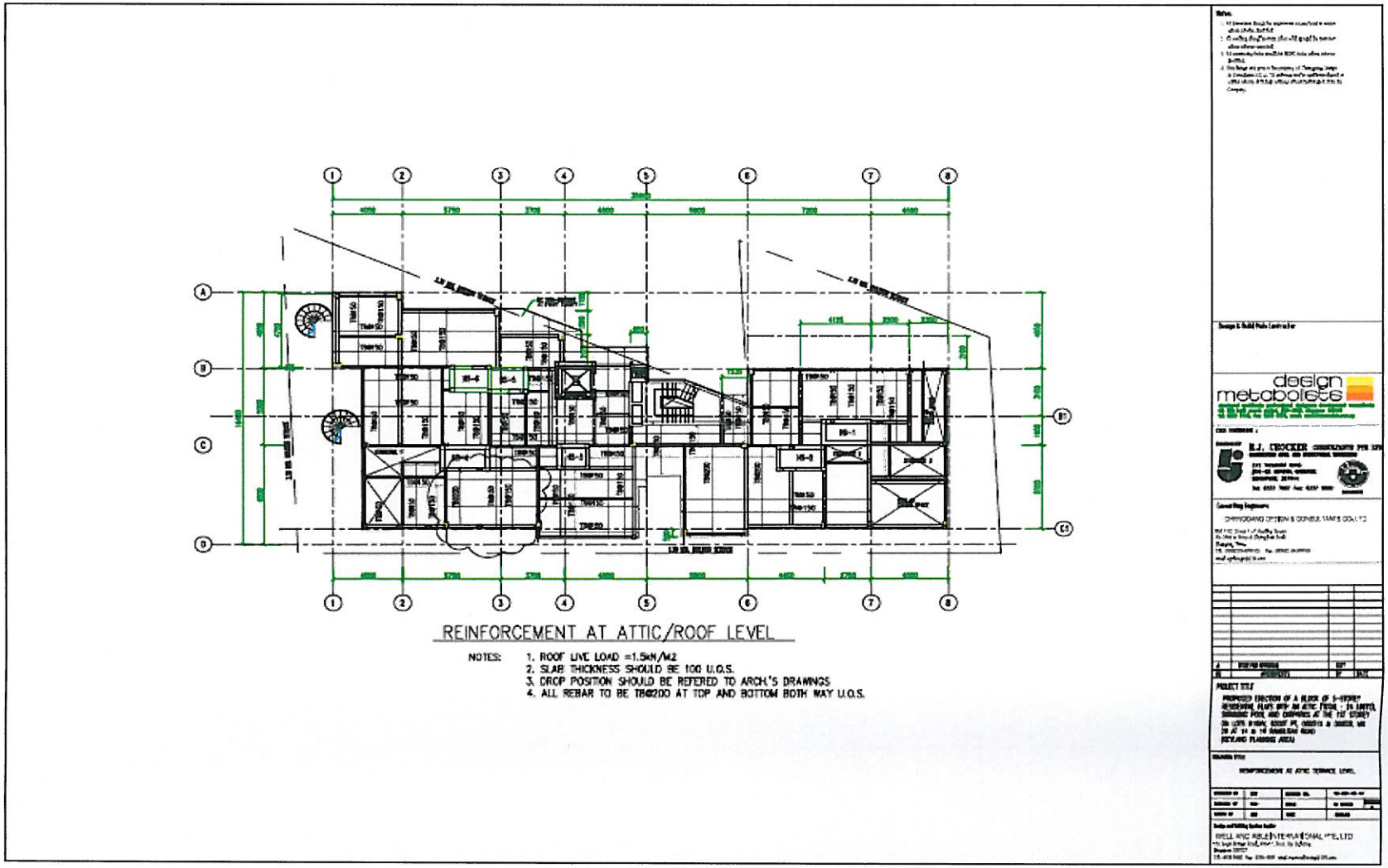


Figure 26: Reinforcement at attic terrace level

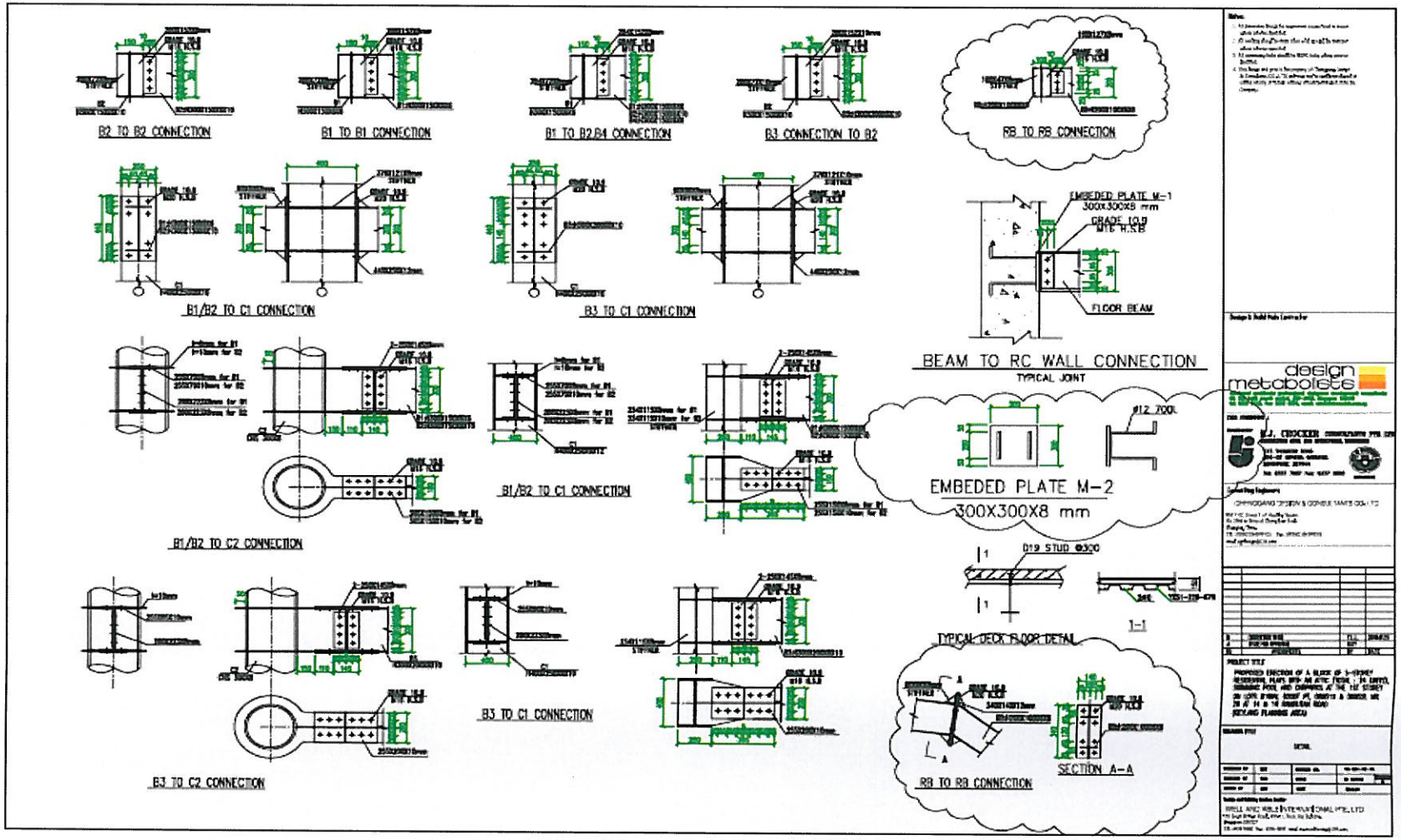


Figure 27 : Detailing of connection

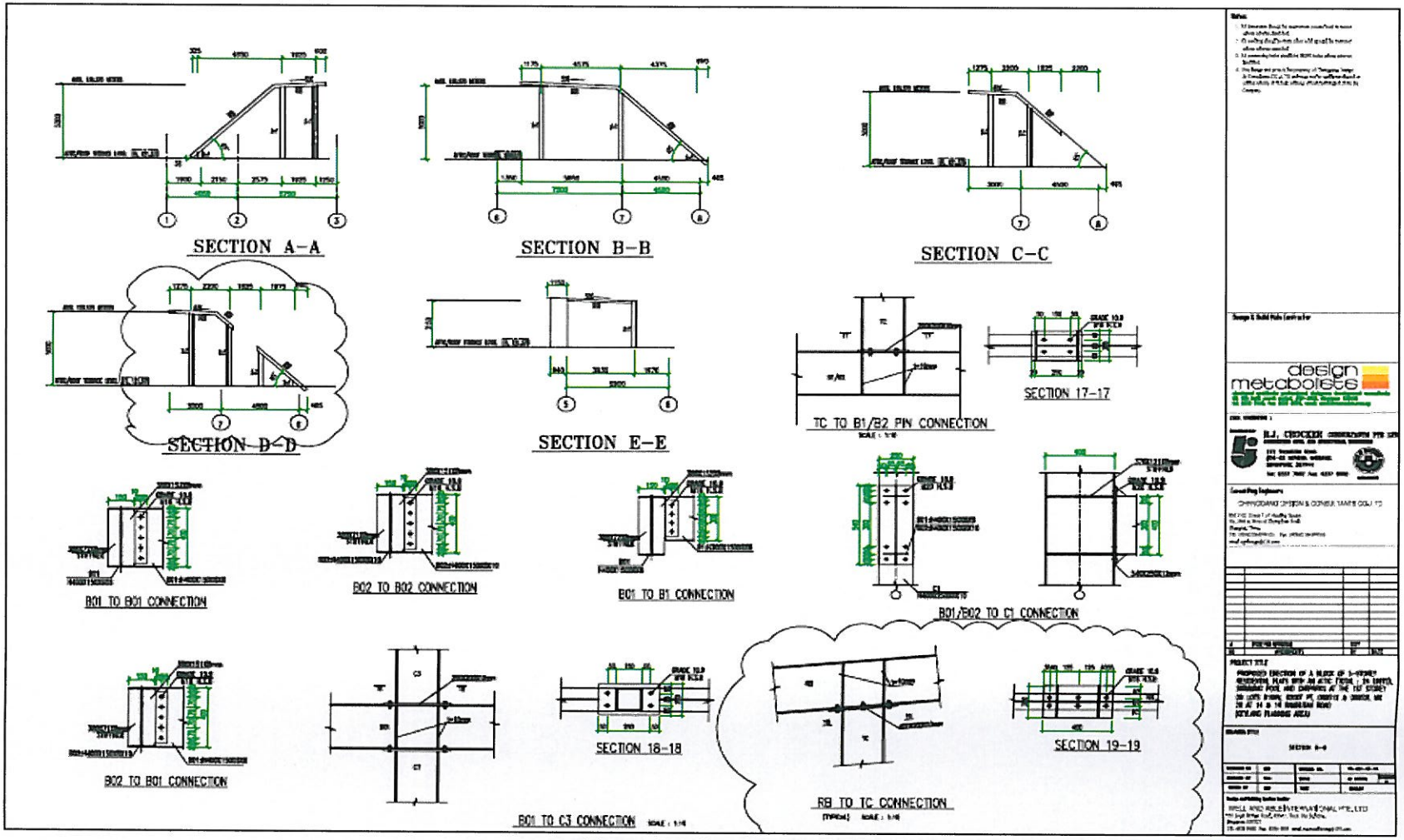


Figure 28 : Section B-B

Figure 29 : Side view of finished project five (5) storey residential apartment at Rambutan Road, Singapore.

Figure 30 : Finished project of five (5) storey residential apartment at Rambutan Road, Singapore.

6.4 Frame Analysis and Design

STAAD Pro Analysis Software was used for the frame analysis. The frame analysis report using StaadPro is shown in the following Figure 30 - Figure 35. Prokon Design Software is used for connection design. In Singapore, the structural component design is based on design codes as mentioned in Section 6.3. The design for connections is found to be satisfactory. The recommendation given for this technical report is based on the design submitted by WASB. For further details on other design calculations, need to refer WASB.

STAAD.Pro Report

To: From:

Copy to: Date: 05/07/2009 21:42:00 Ref:

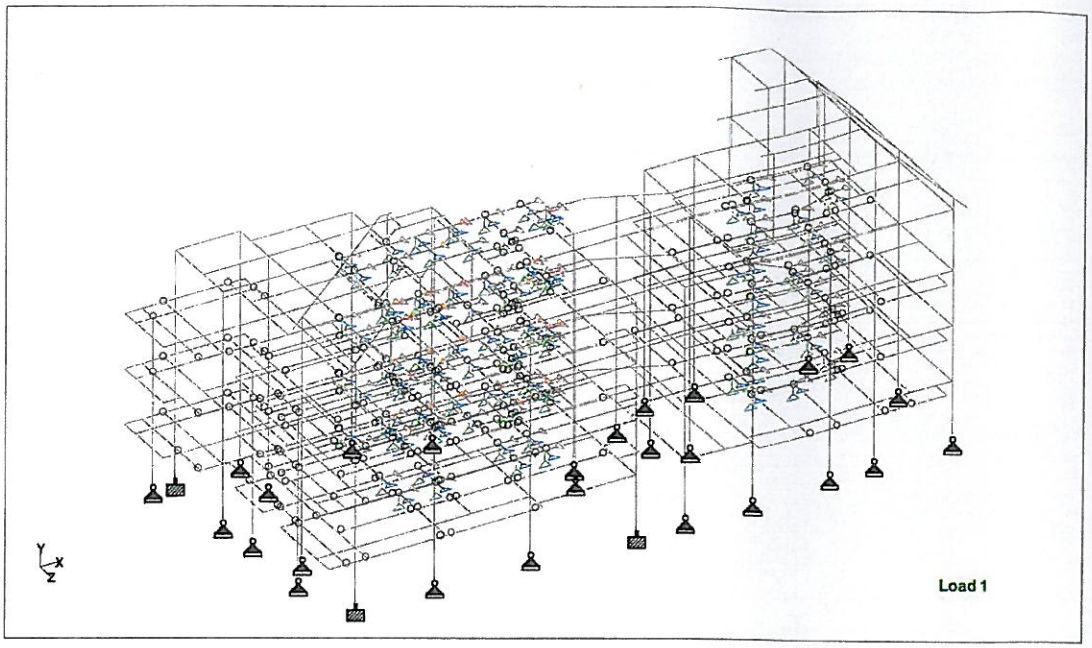


Figure 31 : 3D view of modelling structure

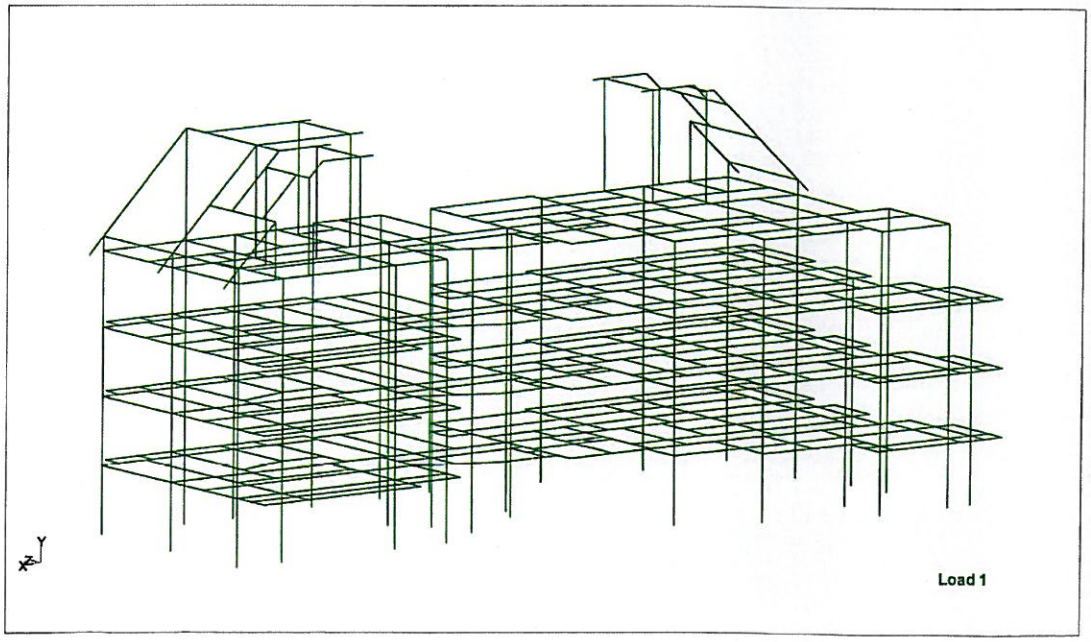


Figure 32 : Design result

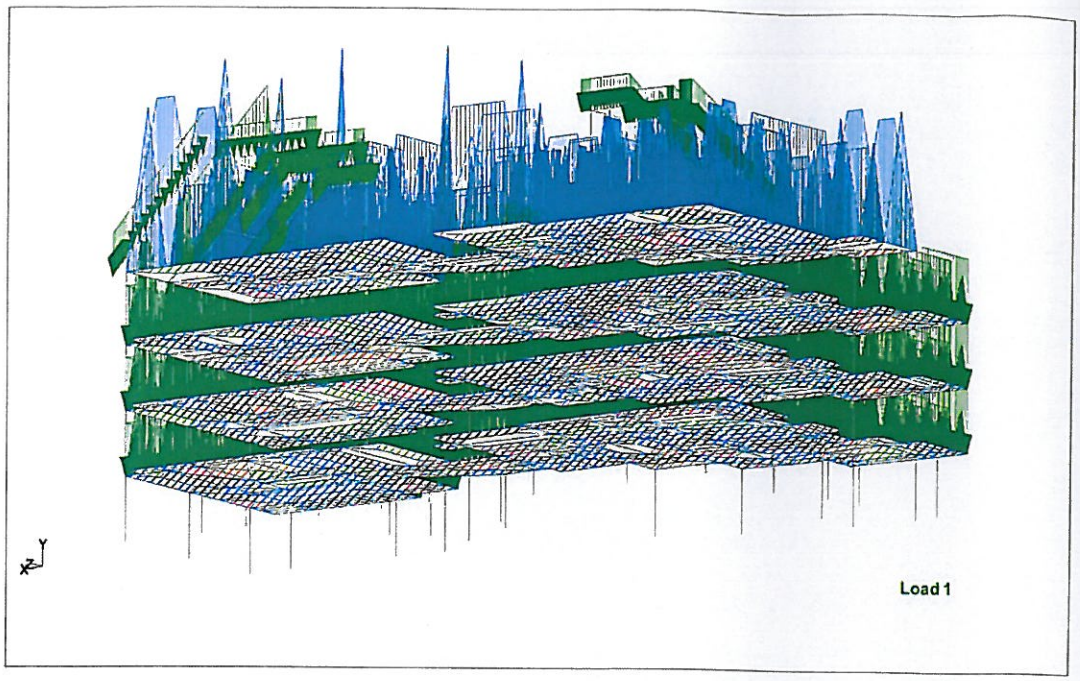


Figure 33 : Dead load (DL)

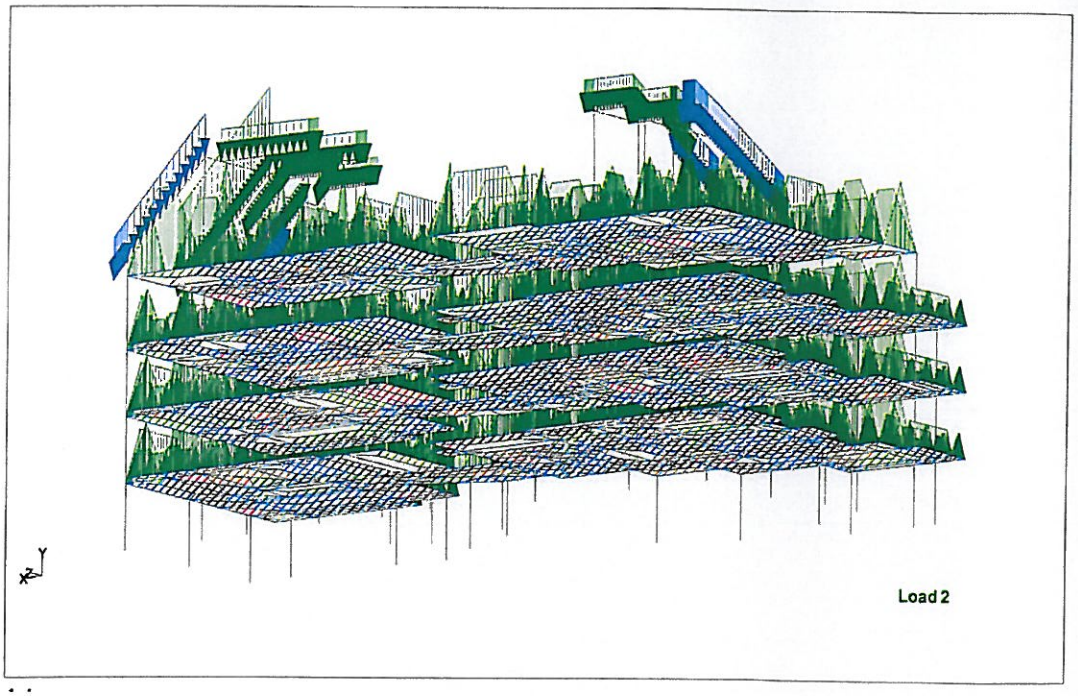


Figure 34 : Live load (LL)

The frame analysis shows the stress distribution and intensity due to dead load and live loads imposed to the structure.

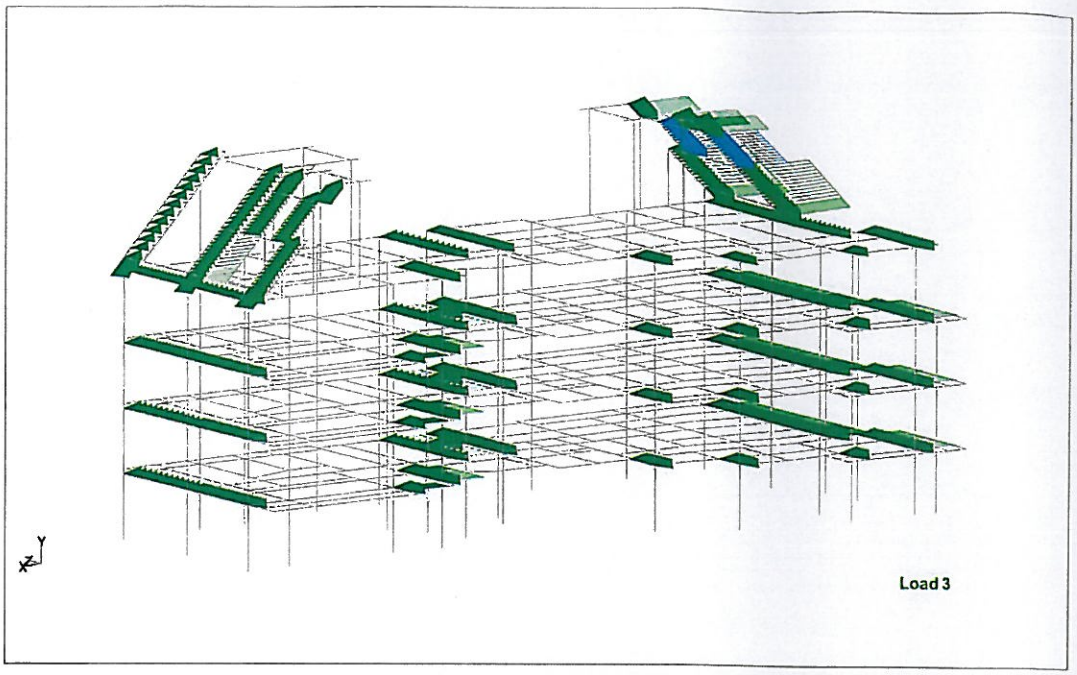


Figure 35 : WLX

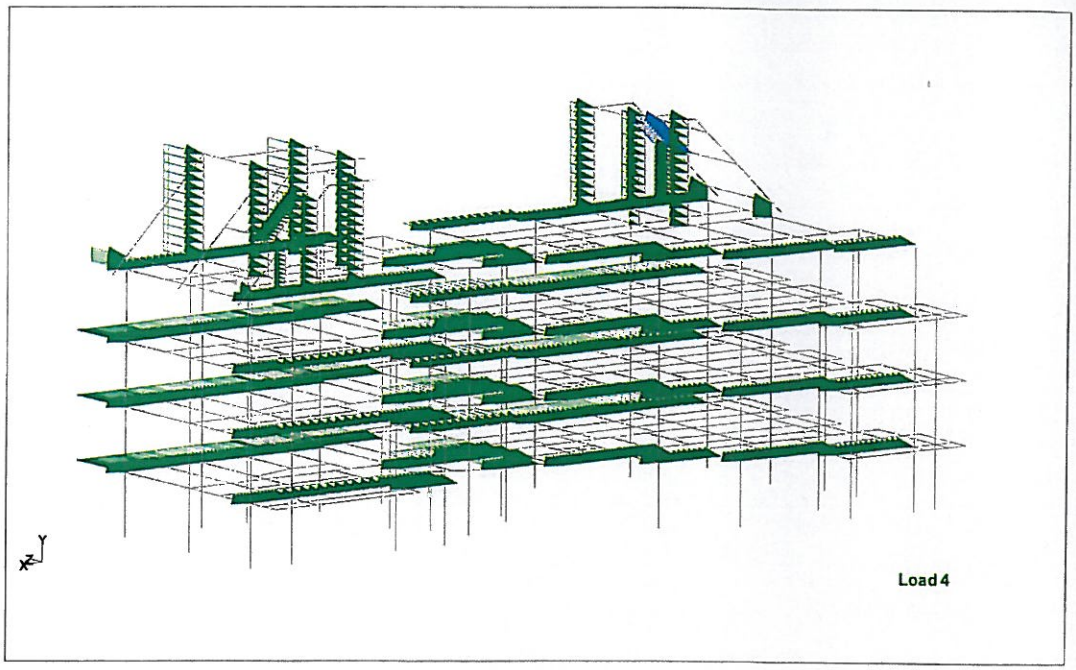


Figure 36 : WLZ

Frame analysis using StaadPro shows that the design for the section used for this building is satisfactory.

6.5 House Shelter and Loading Calculation

The following table tabulates the house shelter and the loading calculation as provided by WASB.

Project PROPOSED ERECTION OF 1 BLOCK OF 5-STOREY RESIDENTIAL APARTMENT (TOTAL:24 UNITS) WITH ATTIC, ROOF TERRACE, SWIMMING POOL AND COMMUNAL FACILITIES ON LOT/S 06199V, 06951X 06952L AND 06200T MK 26 AT RAMBUTAN ROAD (GEYLANG PLANNING AREA)

Loading for Steel Column

Shelt Mark	Column Mark	Area	3rd		4th		5th		Roof		DL (kN)	LL(kN)
			DL (kN)	LL(kN)	DL (kN)	LL(kN)	DL (kN)	LL(kN)	DL (kN)	LL(kN)		
HS-1	HS-1-1	10.28	57.57	15.42	57.57	15.42	57.57	15.42	67.85	15.42	245.7	61.7
	HS-1-2	7.60	42.56	11.40	42.56	11.40	42.56	11.40	50.16	11.40	181.6	45.6
	HS-1-3	11.97	67.03	17.96	67.03	17.96	67.03	17.96	79.00	17.96	286.1	71.8
HS-2	HS-2-1	4.18	23.41	6.27	23.41	6.27	23.41	6.27	27.59	6.27	99.9	25.1
	HS-2-2	7.29	40.82	10.94	40.82	10.94	40.82	10.94	48.11	10.94	174.2	43.7
	HS-2-3	5.84	32.70	8.76	32.70	8.76	32.70	8.76	38.54	8.76	139.6	35.0
	HS-2-4	6.96	38.98	10.44	38.98	10.44	38.98	10.44	45.94	10.44	166.3	41.8
HS-3	HS-3-1	7.25	40.60	10.88	40.60	10.88	40.60	10.88	47.85	10.88	173.3	43.5
	HS-3-2	9.50	53.20	14.25	53.20	14.25	53.20	14.25	62.70	14.25	227.1	57.0
	HS-3-3	7.90	44.24	11.85	44.24	11.85	44.24	11.85	52.14	11.85	188.8	47.4
	HS-3-4	6.03	33.77	9.05	33.77	9.05	33.77	9.05	39.80	9.05	144.1	36.2
HS-4	HS-4-1	11.60	64.96	17.40	64.96	17.40	64.96	17.40	76.56	17.40	277.2	69.6
	HS-4-2	12.59	70.50	18.89	70.50	18.89	70.50	18.89	83.09	18.89	300.9	75.5
	HS-4-3	9.54	53.42	14.31	53.42	14.31	53.42	14.31	62.96	14.31	228.0	57.2
	HS-4-4	8.80	49.28	13.20	49.28	13.20	49.28	13.20	58.08	13.20	210.3	52.8
HS-5,6	HS-5-1	6.72	37.63	10.08	37.63	10.08	37.63	10.08	44.35	10.08	160.6	40.3
	HS-5-2	7.78	43.57	11.67	43.57	11.67	43.57	11.67	51.35	11.67	185.9	46.7
	HS-5-3	3.88	21.73	5.82	21.73	5.82	21.73	5.82	25.61	5.82	92.7	23.3
	HS-6-1	5.46	30.58	8.19	30.58	8.19	30.58	8.19	36.04	8.19	130.5	32.8
	HS-6-2	6.59	36.90	9.89	36.90	9.89	36.90	9.89	43.49	9.89	157.5	39.5
	HS-6-3	4.68	26.21	7.02	26.21	7.02	26.21	7.02	30.89	7.02	111.9	28.1
HS-4	LC-1	2.57	14.36	3.85	14.36	3.85	14.36	3.85	16.93	3.85	61.3	15.4
	LC-2	4.16	23.31	6.24	23.31	6.24	23.31	6.24	27.48	6.24	99.5	25.0
	LC-3	4.70	26.30	7.05	26.30	7.05	26.30	7.05	31.00	7.05	112.3	28.2
	LC-4	1.32	7.39	1.98	7.39	1.98	7.39	1.98	8.71	1.98	31.5	7.9
REFUSE CHUTE		15.85	88.76	23.78	88.76	23.78	88.76	23.78	104.61	23.78	378.8	95.1
RC STAIRCASE WALL		6.45	36.12	9.68	36.12	9.68	36.12	9.68	42.57	9.68	154.2	38.7

Note: Above loading does not including RC WALL self weight.

Loading for Steel Column

	Column Mark	Area	3rd		4th		5th		Roof		DL (kN)	LL(kN)
			DL (kN)	LL(kN)	DL (kN)	LL(kN)	DL (kN)	LL(kN)	DL (kN)	LL(kN)		
Steel column	C2-1	10.59	59.30	15.89	59.30	15.89	59.30	15.89	69.89	15.89	253.1	63.5
	C1-2	13.35	74.76	20.03	74.76	20.03	74.76	20.03	88.11	20.03	319.1	80.1
	C1-3	8.73	48.89	13.10	48.89	13.10	48.89	13.10	57.62	13.10	208.6	52.4
	C1-4	11.13	62.33	16.70	62.33	16.70	62.33	16.70	73.46	16.70	266.0	66.8
	C1-5	16.93	94.81	25.40	94.81	25.40	94.81	25.40	111.74	25.40	404.6	101.6
	C1-6	11.90	66.64	17.85	66.64	17.85	66.64	17.85	78.54	17.85	284.4	71.4
	C1-7	11.08	62.05	16.62	62.05	16.62	62.05	16.62	73.13	16.62	264.8	66.5
	C2-8	12.96	72.58	19.44	72.58	19.44	72.58	19.44	85.54	19.44	309.7	77.8
	C1-9	15.92	89.15	23.88	89.15	23.88	89.15	23.88	105.07	23.88	380.5	95.5
	C1-10	16.64	93.18	24.96	93.18	24.96	93.18	24.96	109.82	24.96	397.7	99.8
	C1-11	7.11	39.82	10.67	39.82	10.67	39.82	10.67	46.93	10.67	169.9	42.7
	C1-13	12.25	68.60	18.38	68.60	18.38	68.60	18.38	80.85	18.38	292.8	73.5
	C2-14	8.77	49.11	13.16	49.11	13.16	49.11	13.16	57.88	13.16	209.6	52.6
	C1-15	7.36	41.22	11.04	41.22	11.04	41.22	11.04	48.58	11.04	175.9	44.2
	C1-16	4.52	25.30	6.78	25.30	6.78	25.30	6.78	29.82	6.78	108.0	27.1
	C1-18	7.76	43.46	11.64	43.46	11.64	43.46	11.64	51.22	11.64	185.5	46.6
	C1-19	11.70	65.52	17.55	65.52	17.55	65.52	17.55	77.22	17.55	279.6	70.2
	C1-20	6.42	35.95	9.63	35.95	9.63	35.95	9.63	42.37	9.63	153.4	38.5
	C1-21	13.63	76.33	20.45	76.33	20.45	76.33	20.45	89.96	20.45	325.8	81.8
	C1-22	15.26	85.46	22.89	85.46	22.89	85.46	22.89	100.72	22.89	364.7	91.6
	C1-23	15.46	86.58	23.19	86.58	23.19	86.58	23.19	102.04	23.19	369.5	92.8
	C1-24	8.50	47.60	12.75	47.60	12.75	47.60	12.75	56.10	12.75	203.2	51.0
	C1-25	11.00	61.60	16.50	61.60	16.50	61.60	16.50	72.60	16.50	262.9	66.0
	C1-26	10.66	59.70	15.99	59.70	15.99	59.70	15.99	70.36	15.99	254.8	64.0
	C1-27	13.95	78.12	20.93	78.12	20.93	78.12	20.93	92.07	20.93	333.4	83.7
	C2-28	8.09	45.30	12.14	45.30	12.14	45.30	12.14	53.39	12.14	193.4	48.5

Total dead load of the building above 2nd storey is 11690.8 kN

20kN/m^2 collapse load on 2nd storey is 9780 kN

So designed collapse dead load on transfer structure is 11690.76 kN

Loading for each floor

Floor	Weight kN/m^2		SDL kN/m^2	LL kN/m^2
3rd floor	120mm Slab self weight	3.00	5.6	1.5
	Steel structure	0.50		
	Finish/partitions	1.50		
	M&E	0.35		
	Ceiling	0.25		
4th floor	120mm Slab self weight	3.00	5.6	1.5
	Steel structure	0.50		
	Finish/partitions	1.50		
	M&E	0.35		
	Ceiling	0.25		
5th floor	120mm Slab self weight	3.00	5.6	1.5
	Steel structure	0.50		
	Finish/partitions	1.50		
	M&E	0.35		
	Ceiling	0.25		
Roof	120mm Slab self weight	3.00	6.6	1.5
	Steel structure	0.50		
	Water Proof	2.50		
	M&E	0.35		
	Ceiling	0.25		
Summary			23.4	6

6.6 Connection Calculation

WASB also provides the details of the connection calculation. The details are tabulated as follows:

PROKON
Software Consultants (Pty) Ltd
Internet: http://www.prokon.com
E-Mail : mail@prokon.com

Job Number		Sheet
Job Title		
Client		
Calcs by	Checked by	Date

S12

Beam - Column Connection - Ver W2.1.01 - 28 Sep 2004

Title : B1 TO C1 CONNECTION
Code of Practice : BS5950 - 2000
Created : 2009-7-3 13:45:17

Notes and Assumptions

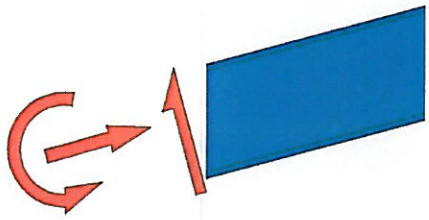
1 All bolt holes are assumed to be normal clearance holes.
2 All bolts are assumed to have threads in their shear planes.
3 It is assumed that the connection is deep enough for the flanges to resist the compressive and tensile forces in them.
4 It is assumed that compressive forces in flanges and stiffeners are conveyed through welds and not through bearing.
5 Axial force in the column is not considered in the design.
5 HSFG bolts are designed for non-slip under factored loads.

Summary

Summary of Forces and Capacities for Design to BS5950 - 2000

Check	Member	Type	LC	Applied	Capacity	Units	% of Cap.	?
1	Weld	Flange	COMBINED	282.6	293.1	kN	96.4	O.K.
2	Weld	Web	COMBINED	95	574.2	kN	16.5	O.K.
3	Column Web	Tension Yielding	COMBINED	282.6	1733.8	kN	16.3	O.K.
4	Column Web	Compression Crippling	COMBINED	227.6	700.6	kN	32.5	O.K.
5	Column Web	Compression Buckling	COMBINED	227.6	966.9	kN	23.5	O.K.
6	Column Web	Shear	COMBINED	282.6	604.8	kN	46.7	O.K.
7	Bolts & Flange	Tension & Bending	COMBINED	156.8	202.8	kN	77.3	O.K.
8	Column Flange	Bearing	COMBINED	11.9	63.1	kN	18.8	O.K.
9	Bolts & End Plate	Tension & Bending	COMBINED	156.8	202.8	kN	77.3	O.K.
10	End Plate	Bearing	COMBINED	11.9	63.1	kN	18.8	O.K.
11	Bolts	Shear	COMBINED	11.9	91.9	kN	12.9	O.K.
12	Bolts	Shear & Tension	COMBINED	0.7	1.4	kN	50	O.K.
13	Bolts	Slip	COMBINED	95	423.4	kN	22.4	O.K.

Input



Ultimate Limit State Loads in Beam				SLS Factor
Load Case	Shear	Axial	Moment	
COMBINED	95	-55	75	1

End Plate	Width	(mm)	250
	Extent Above Beam Flange	(mm)	70
	Extent Below Beam Flange	(mm)	70
	Thickness	(mm)	12
	Stiffeners		Both
Column Stiffeners	Width	(mm)	120
	Top Stiffener Thickness	(mm)	8
	Bottom Stiffener Thickness	(mm)	8
	Shear Stiffener Thickness	(mm)	None
	Shear Stiffener Orientation		None
Web Plates	Layout		None
	Thickness	(mm)	None
Top Backing Plate	Thickness	(mm)	None
Bottom Backing Plate	Thickness	(mm)	None
Bolts	Diameter	(mm)	20
Rows of Bolts	Above Top Flange		1
	Below Top Flange		1
	Above Bottom Flange		1
	Below Bottom Flange		1
	Row Spacing	(mm)	N/A
Bolt Offsets	Web	(mm)	50
	Flange	(mm)	50
	Above Haunch	(mm)	N/A
Welds	Beam Flanges		6
	Beam Web	(mm)	6
	Top Stiffener	(mm)	6
	Bottom Stiffener	(mm)	6
	Shear Stiffener	(mm)	N/A

Capacity of the Stiffeners

The capacity of the applicable stiffener is the lesser of the capacity of the plate and the capacity of the stiffener welds.

Top Stiffener : Weld

The Capacity of weld is the lesser of : 6.8.5

$$P_s = \frac{0.5 \cdot A_w \cdot U_e}{1000}$$
$$= \frac{0.5 \times 2\,036.16 \times 470}{1000}$$
$$= 478.498 \text{ kN}$$

$$P_s = \frac{0.55 \cdot A_w \cdot U_s}{1000}$$
$$= \frac{0.55 \times 2\,036.16 \times 470}{1000}$$
$$= 526.347 \text{ kN}$$

Top Stiffener : Tension 4.5.4

$$P_s = \frac{2 \cdot t \cdot b \cdot p_y}{1000}$$
$$= \frac{2 \times 8 \times 120 \times 315}{1000}$$
$$= 604.800 \text{ kN}$$

Top Stiffener : Compression 4.5.2/3

$$P_s = \frac{2 \cdot t \cdot b \cdot p_y}{1000}$$
$$= \frac{2 \times 8 \times 120 \times 315}{1000}$$
$$= 604.800 \text{ kN}$$

Bottom Stiffener : Weld

The Capacity of weld is the lesser of : 6.8.5

$$P_s = \frac{0.5 \cdot A_w \cdot U_e}{1000}$$
$$= \frac{0.5 \times 2\,036.16 \times 470}{1000}$$
$$= 478.498 \text{ kN}$$

$$P_S = \frac{0.55 \cdot A_W \cdot U_S}{1000}$$

$$= \frac{0.55 \times 2\,036.16 \times 470}{1000}$$

$$= 526.347 \text{ kN}$$

Bottom Stiffener : Tension

4.5.4

$$P_S = \frac{2 \cdot t \cdot b \cdot p_y}{1000}$$

$$= \frac{2 \times 8 \times 120 \times 315}{1000}$$

$$= 604.800 \text{ kN}$$

Bottom Stiffener : Compression

4.5 2/3

$$P_S = \frac{2 \cdot t \cdot b \cdot p_y}{1000}$$

$$= \frac{2 \times 8 \times 120 \times 315}{1000}$$

$$= 604.800 \text{ kN}$$

Check 1 : Capacity of the Beam Flange Welds

The worst load is encountered for Load Case : COMBINED
B_{max} = **282.602 kN**

The Capacity of the weld is the lesser of :

6.8.5

$$P_W = \frac{0.5 \cdot A_W \cdot U_e}{1000}$$

$$= \frac{0.5 \times 1\,247.336 \times 470}{1000}$$

$$= 293.124 \text{ kN}$$

$$P_W = \frac{0.55 \cdot A_W \cdot U_S}{1000}$$

$$= \frac{0.55 \times 1\,247.336 \times 470}{1000}$$

$$= 322.436 \text{ kN}$$

Beam Flange Weld is safe

Check 2 : Capacity of the Beam Web Welds

The worst load is encountered for Load Case : COMBINED
B_{max} = **95 kN**

The Capacity of the weld is the lesser of : 6.8.5

$$P_w = \frac{0.5 \cdot A_w \cdot U_e}{1000}$$
$$= \frac{0.5 \times 1\,247.148 \times 470}{1000}$$
$$= 293.080 \text{ kN}$$

$$P_w = \frac{0.55 \cdot A_w \cdot U_s}{1000}$$
$$= \frac{0.55 \times 1\,247.148 \times 470}{1000}$$
$$= 322.388 \text{ kN}$$

Beam Web Weld is safe

Check 3 : Capacity of the Column web in tension

Opposite Top flange of the beam :

The worst load is encountered for Load Case : COMBINED
when T_{max} =**282.602 kN**

The Capacity of the web is : 4.5.4

$$P_t = \frac{t_w \cdot l_{eff} \cdot p_y}{1000}$$
$$= \frac{8 \times 500 \times 315}{1000}$$
$$= 1\,260.000 \text{ kN}$$

But due to the stiffeners the resistance is :

$$P_{teff} = P_t + P_s$$
$$= 1\,260.000 + 473.76$$
$$= 1\,733.760 \text{ kN}$$

No tensile forces in the beam bottom flange

Column web is safe in tension

Check 4 : Crippling Capacity of the Column web in Compression

No compressive forces in the beam top flange

Opposite Bottom flange of the beam :

The worst load is encountered for Load Case : COMBINED
when Fx_{max} =**227.602 kN**

The Capacity of the web is :

4.5.2

$$P_{bw} = \frac{(b_1 + n \cdot k) \cdot t_w \cdot p_w}{1000}$$

$$= \frac{(30 + 5 \times 12) \times 8 \times 315}{1000}$$

$$= 226.800 \text{ kN}$$

But due to the stiffeners the resistance is :

$$P_{eff} = P_{bw} + P_s$$

$$= 226.800 + 473.76$$

$$= 700.560 \text{ kN}$$

Column web is safe in compression for crippling

Check 5 : Buckling Capacity of the Column web in Compression

No compressive forces in the top beam flange

Opposite Bottom flange of the beam :

The worst load is encountered for Load Case : COMBINED
when Fx_{max} =**227.602 kN**

Assumptions : 1) Bearing flange is restrained against rotation relative to the web
2) Bearing flange is restreined against lateral movement relative to the outer flange

4.5.3.3

$$\lambda = \frac{K_e \cdot l}{r}$$

$$= \frac{0.7 \times 376}{56.678}$$

$$= 4.644$$

$$\lambda_o = 0.2 \cdot \left[\frac{\pi^2 \cdot E}{p_y}\right]^{0.5}$$

$$= 0.2 \times \left[\frac{\pi^2 \times 200000}{315}\right]^{0.5}$$

$$= 15.832$$

$$\eta = 0.001 \cdot \alpha \cdot (\lambda - \lambda_o)$$

$$= 0.001 \times 5.5 \times (4.644 - 15.832)$$

$$= -0.062$$

But #h>=0

$$\eta = 0$$

$$pE = \frac{\pi^2 \cdot E}{\lambda^2}$$

$$= \frac{\pi^2 \times 200000}{4.644^2}$$

$$= 91.53 \times 10^3$$

$$\phi = \frac{p_y + (\eta + 1) \cdot pE}{2}$$

$$= \frac{315 + (0.000 \times 10^0 + 1) \times 91.53 \times 10^3}{2}$$

$$= 45.92 \times 10^3$$

$$p_c = \frac{pE \cdot p_y}{\phi + \left[\phi^2 - pE \cdot p_y\right]^{0.5}}$$

$$= \frac{91.53 \times 10^3 \times 315}{45.92 \times 10^3 + \left[45.92 \times 10^{32} - 91.53 \times 10^3 \times 315\right]^{0.5}}$$

$$= 315.000$$

$$P_c = \frac{p_c \cdot A}{1000}$$

$$= \frac{315.000 \times 2880}{1000}$$

$$= 907.200 \text{ kN}$$

Column web is safe in compression for buckling

Check 6 : Shear Capacity of the Column Web

The worst load is encountered for Load Case : COMBINED
when F_v =**282.602 kN**

4.5.6
4.2.3

$$P_v = \frac{0.6 \cdot p_y \cdot A_v}{1000}$$
$$= \frac{0.6 \times 315 \times 3200}{1000}$$
$$= 604.800 \text{ kN}$$

Column web shear is safe

Check 7 : Bolt tension and Column Flange Bending

The worst load is encountered for Load Case : COMBINED

F_{max} = **156.788 kN**

The resistance is the smaller of the 3 possible failure modes :

Mode 1 : Complete yielding of the flange

$$R_1 = \frac{4 \cdot M_{pl} + 2 \cdot M_{bp}}{m} \cdot 1000$$
$$= \frac{4 \times 2.835 + 2 \times 0}{50} \times 1000$$
$$= 226.800 \text{ kN}$$

Mode 2 : Bolt Failure with yielding of the flange

$$R_2 = \frac{2 \cdot M_{pl} \cdot 1000 + n \cdot 2 \cdot B_t}{m + n}$$
$$= \frac{2 \times 2.835 \times 1000 + 62.5 \times 2 \times 137.2}{50 + 62.5}$$
$$= 202.844 \text{ kN}$$

Mode 3 : Bolt Failure only

$$R_3 = 2 \cdot B_t$$
$$= 2 \times 137.2$$
$$= 274.400 \text{ kN}$$

Therefore R = R2 = 202.844

Bolt tension and Column Flange bending is safe

Check 8 : Bearing on the Column Flange

The worst load is encountered for Load Case : COMBINED
with Fb = **11.875 kN**

The Bearing Capacity of the Flange at any Bolt is the lesser of :

6.3.3.2

$$P_{bb} = \frac{d \cdot t_p \cdot p_{bb}}{1000}$$

$$= \frac{20 \times 12 \times 1008}{1000}$$

$$= 241.920 \text{ kN}$$

And

6.3.3.3

$$P_{bs} = \frac{d \cdot t_p \cdot p_{bs}}{1000}$$

$$= \frac{20 \times 12 \times 525.95}{1000}$$

$$= 126.228 \text{ kN}$$

And

6.3.3.3

$$P_{bs} = \frac{\frac{1}{2} \cdot e \cdot t_p \cdot p_{bs}}{1000}$$

$$= \frac{\frac{1}{2} \times 20 \times 12 \times 525.95}{1000}$$

$$= 63.114 \text{ kN}$$

Column flange bearing is safe

Check 9 : Bolt tension and End Plate Bending

The worst load is encountered for Load Case : COMBINED

F_{max} = **156.788 kN**

The resistance is the smaller of the 3 possible failure modes :

Mode 1 : Complete yielding of the End Plate

$$R_1 = \frac{4 \cdot M_{pl}}{m} \cdot 1000$$

$$= \frac{4 \times 2.61954}{46.2} \times 1000$$

$$= 226.800 \text{ kN}$$

Mode 2 : Bolt Failure with yielding of the End Plate

$$R_2 = \frac{2 \cdot M_{pl} \cdot 1000 + n \cdot 2 \cdot B_t}{m + n}$$

$$= \frac{2 \times 2.61954 \times 1000 + 57.75 \times 2 \times 137.2}{46.2 + 57.75}$$

$$= 202.844 \text{ kN}$$

Mode 3 : Bolt Failure only

$$R_3 = 2 \cdot B_t$$

$$= 2 \times 137.2$$

$$= 274.400 \text{ kN}$$

Therefore R = R2 = 202.844

Bolt tension and End Plate bending is safe

Check 10 : Bearing on the End Plate

The worst load is encountered for Load Case : COMBINED
with Fb = **11.875 kN**

The Bearing Capacity of the Flange at any Bolt is the lesser of : 6.3.3.2

$$P_{bb} = \frac{d \cdot t_p \cdot p_{bb}}{1000}$$

$$= \frac{20 \times 12 \times 1008}{1000}$$

$$= 241.920 \text{ kN}$$

And 6.3.3.3

$$P_{bs} = \frac{d \cdot t_p \cdot p_{bs}}{1000}$$
$$= \frac{20 \times 12 \times 525.95}{1000}$$
$$= 126.228 \text{ kN}$$

And

6.3.3.3

$$P_{bs} = \frac{\frac{1}{2} \cdot e \cdot t_p \cdot p_{bs}}{1000}$$
$$= \frac{\frac{1}{2} \times 20 \times 12 \times 525.95}{1000}$$
$$= 63.114 \text{ kN}$$

End plate bearing is safe

Check 11 : Shear Capacity of the Bolts

The worst load is encountered for Load Case : COMBINED
when Fs_{max} **=11.875 kN**

6.3.2

The resistance of any bolt is :

$$P_s = \frac{p_s \cdot A_s}{1000}$$
$$= \frac{375 \times 245}{1000}$$
$$= 91.875 \text{ kN}$$

Bolt shear is safe

Check 12 : Shear and Tension Capacity of the Bolts

The worst load is encountered for Load Case : COMBINED

6.3.4.4

The factor must be less than or equal to **1.4** :

$$F_{actor} = \frac{F_s}{P_s} + \frac{F_t}{P_t}$$
$$= \frac{11.875}{91.875} + \frac{78.394}{137.2}$$
$$= 0.701$$

Bolt shear and tension is safe

Check 13 : Slip Capacity of the Bolts

The worst load is encountered for Load Case : COMBINED
Fs_{max} = **95 kN**

6.4.2

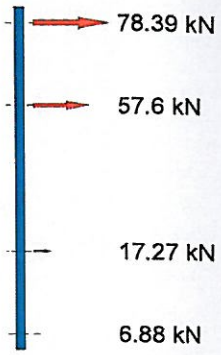
where the resistance of any bolt is :

$$P_{sL} = 0.9 \cdot K_s \cdot \mu \cdot P_o$$
$$= 0.9 \times 1.0 \times 0.40 \times 147$$
$$= 52.920 \text{ kN}$$

Bolt slip is safe

Bolt Forces

Bolt Forces for Load Case : COMBINED



Shear force per bolt : 11.88 kN

7.0 GREEN PRODUCT

The products are yet to be certified as green product as no relevant document to support the claim is presented to the Technical Expert Panel. It is recommended that the WASB make an effort to confirm the product to be green through the authority in Malaysia.

8.0 MODULAR INDUSTRIALISED PRODUCT

The products are yet to be certified as IBS product according to MS 1064 as no relevant document to support the claim is presented to the Technical Expert Panel. It is recommended that the WASB make an effort to confirm the products are IBS components.

9.0 VALIDITY OF THE OPINION

9.1 Condition

The Technical Opinion Report given herein is based on the experiences of the Technical Expert Panel. This report applies to the documents of the specific product submitted. The reports are not used to indicate or imply that they are applicable to other similar items. The recommendations are based on and limited to the available information provided by Applicant including documents on the product details and test reports from accredited laboratories. The recommendations are also based on and limited to the available information provided by Applicant and during the interview session conducted between the Technical Expert Panel and representatives from the Applicant on 4th January 2012.

9.2 Withdrawal

In the event of non compliance to the international standard or any other equivalent and resemblance standards, it will lead to withdrawal of this opinion.

9.3 Term of Validity

The recommendations are valid for three (3) years from the date of issuance of this Technical Opinion Report. This report is valid from July 2012 to June 2015.

10.0 RELEVANT DOCUMENTS

10.1 Standard and Test Report

The standard adopted for the tests were stated. However, the client name and the product name in the report are different from the Applicant and Adresses (refer Section 1.3). The year of report is more than five (5) years. It is recommended to produce new test report.

Nevertheless, the letter that produced by dated 23rd May 2012 verifies the products that submitted by the Applicant for the tests are same as applied for the evaluation (refer to Appendix D).

10.2 QA / QC Plan Document

QA/QC plan document for the purpose of purchasing parts, materials, processing and assembling used in the installation system are provided in this report. This document is important to ensure quality in production is observed at all time during process of making the components. The QA/ QC Plan is attached in Appendix E.

11.0 APPROVED OPINION ABSTRACT

The Technical Expert Panel is in the opinion that products from WASB are in general suitable to be used in Malaysia provided that it complies with the terms and condition mentioned in this report. The products are recommended to be used as a complete system and have to be in compliance with local Building By Law and the design shall be in compliance with current relevant design codes and standards.

All components and materials test were performed in accordance with foreign standards, however it is recommended that these tests to be conducted locally in accordance with Malaysian Standard or any equivalent and accepted International Standard to be done at accredited laboratories.

12.0 RECOMMENDATIONS

Recommendations by Technical Expert Panels are as follows :

a. The use of HFW H Section, ALCP and Besta Board Panel requires advice and involvement from professional.
b. Any batch of the products traded by the Applicant shall be tested and evaluated by relevant local authorities.

c. The materials content of the product shall comply with Malaysian Standard for testing of material. The test reports submitted indicated the standards used for testing HFW H Section were based from Chinese Standard.

d. The Applicant is advised to consult local Accredited Testing Bodies prior to using the HFW H Section, ALCP and Besta Board Panel.

e. The Applicant is advised to adhere to modular design rules (MS 1064) for concrete component (i.e. ALCP) during design of the complete system, so it can be considered as IBS product in Malaysia.

Ir. Dr Zuhairi Abd. Hamid
Technical Opinion Expert Panel

Ir. Mohd Noor Azudin Mansor
Technical Opinion Expert Panel

Ir. Looi Hip Peu
Technical Opinion Expert Panel

Prof. Dr. Rahinah Ibrahim
Technical Opinion Expert Panel

Assoc. Prof. Dr. Hamidah Mohd. Saman
Technical Opinion Expert Panel

July 2012

13.0 REFERENCES

i. **Book**

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ii. **Internet**

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(Date search : 19th June 2012)

http://infostore.saiglobal.com/store/Details.aspx?productID=1082184
(Date search : 19th June 2012)

http://www.wmtr.com/Content/charpy.htm
(Date search : 19th June 2012)

14.0 APPENDIX D

Well & Able International Pte.Ltd.
瑞 能 国 际 有 限 公 司
Address: Rm 202, Block 1, No 427, Jumen Road, shanghai 200023, PRC
Tel: (86)-21-61416325 Fax: (86)-21-61416386

23rd May 2012
To whomever it may concerned
This is to confirmed that the materials used by the following companies to perform the tests are supplied by us

1. **Product : High Frequency Welded Light Gauge Steel Structure**

Tested For :

A) Koon Seng Construction Pte Ltd

Fu Lu Shou Complex , 149 Rochor Road ,

#05-02 Singapore 188425

2. **Product : Autoclaved Light Weight Concrete Panel**

Tested For :

A) GISS Pty Ltd

Ground Floor , 2 Mill Street .

P.O. Box 343 ,

Perth , Western Australia 6000

Australia . Mr Dave Teh

B) Godiniland

Ground Floor , 2 Mill Street ,

P.O. Box 343 ,

Perth , Western Australia 6000

Australia . Mr. Dave Teh

3. **Product : BESTA Board Panel**

Tested For :

A) Best Rock Building System Pte Ltd

14 Zion Road ,

Singapore 247732 Mr. Daniel Wong

B) Godiniland

Ground Floor , 2 Mill Street ,

P.O. Box 343 ,

Perth , Western Australia 6000

Australia . Mr. Dave The

C) Well & Able International Pte Ltd

103 Defu Lane 10

#02-03 BTH Building

Singapore 539223

We trust the above is in good order .

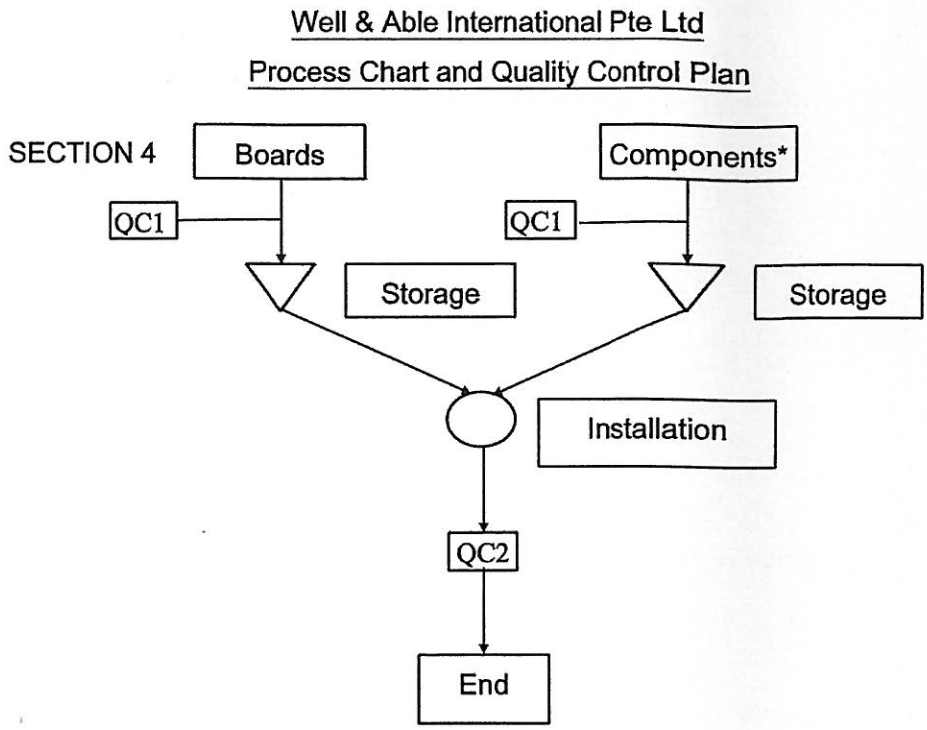
Thank you.

Well & Able International Pte. Ltd.

Signature

15.0 APPENDIX E

QA/QC PLAN



*Components include C- Channels, Rockwool etc. May be supplied by sub-contractors.

Figure 37 : QA / QC plan