行政院及所屬各機關出國報告
（出國類別：其他）

第五綜合實習工廠新建工程
帷幕牆風雨試驗測試

服務機關:國立台灣科技大學
出國人職稱:總務長、組長、技士
姓名:沈進發、李親民、黃則寬
出國地區:新加坡
出國期間:92.03.27-3.30
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報告名稱:

第五綜合實習工廠新建工程帷幕牆風雨測試出國報告書

主辦機關:

國立台灣科技大學

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出國類別: 其他

出國地區: 新加坡

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報告日期: 民國 92 年 06 月 16 日

分類號/目: G4／土木工程　G4／土木工程

關鍵詞: 靜態預壓，氣密性測試，靜態水密性能測試，動態水密性能測試，結構性能測試，側向位移，超結構性能測試。

內容摘要: 本校第五綜合實習工廠新建工程，鋁帷幕外牆構造，爲確保施工品質，在施工前，先製作二層樓高，三跨距寬，包括開窗部實體，按合約施工說明書規定進行各部份組裝構件，所能承受之正負風壓、水密性、氣密性、結構強度等，模擬實際狀況所做的試驗，結果各項試驗皆符合合約規範規定。

目　　錄

一、測試目的

本風雨試驗係本校第五綜合實習工廠新建工程，承包商德昌營造工程股份有限公司，採用工程合約規定廠牌－東信輕金屬股份有限公司，依其所提送本大樓外墻鋁帷幕墻二層樓高，四個直料三跨距寬，包括開窗部實體，按工程合約施工說明書規定進行帷幕墻之鋁擠型、鋁牆板、玻璃之各部相關組裝構件，所能承受之正負風壓、及水密性、氣密性、結構強度等，模擬實際狀況所做之試驗。

二、參加測試各單位及人員

(一)工程名稱:第五綜合實習工廠新建工程

(二)業　　主:國立台灣科技大學總務長
沈進發、營繕組長李親民、技士黃則寬

(三)監造單位:錢紹明建築師事務所
蘇勝銘、李建輝

(四)承 包 商:德昌營造工程股份有限公司
簡慶豪

(五)協力廠商:東信輕金屬服份有限公司
郭俊良、林世雄、鄭宇廷、王重森

(六)生產單位:新加坡 Winwall Technology.pte.LTD

(七)測試單位:新加坡 winwall Technology.pte.LTD 工廠實驗室

(八)測試地點:NO.17 TUASAVE9,Jurong,Singapore 639197
TEL：8622921

三、測試規範及標準

(一)氣密性試驗：

依照 ASIM E 283-84(CNS 13974)規範，測試壓力為 75pa，固定部位漏氣量，不得超過 0.0182m^3(m^3 /min)活動窗之漏氣量不得超過 0.0232m^3(m^3 / min)。

(二)水密性試驗：

靜態水密性試驗依照 ASTM E 331-86(CNS 13974)規範，動態水密性試驗依照 AAMA 501.1(CNS 13973)規範，測試壓力差均為 720pa，噴水量為 4L/Sq.M/Min，持續 15 分鐘，在測試完成前試驗體不得有滲水之現象，但在庇水板，排水槽內之水及凝結水不在此限。

(三)負風壓之結構測試：

依照 ASTM E 330-9(CNS 13972)規範，在進行 100%設計風壓測試後，除防水材如防水塗膠及膠條外，所有材料不可有損壞故障及永久變形，移位之情形，惟容許之永久之變形及移位可為其淨跨距之 0.2%（正風壓 +280Kg/㎡，負風壓-480 Kg/㎡作用下）

(四)側向位移測試：

第一階段之測試位移量左 10mm 右 10mm，重複左右位移各三次，測試後所有試體材料不得有損壞，故障及永久變形移位之情形。

第二階段之測試位移量左 20mm 右 20mm，重複左右位移各三次，測試後所有試體材料不得有損壞，故障及永久變形移位之情形，惟容許之永久變形及移位量可為其淨跨距之 0.2%。

四、試驗程序：

測試項目	測試壓力與要求
(一)簡報	
(二)靜態預壓	壓力差　1375Pa（50%之正風壓）
(三)氣密性測試	壓力差　75Pa
（ASTM E283）	要求　固定部位之漏氣量不得超過 $1.092m^3/hr.m^2$ 活動窗之漏氣量不得超過 $1.392m^3/hr.m^2$。
(四)活動開窗 30 次	
(五)靜態水密性能測試	壓力差　720Pa，噴水量為 $4.0l/min/m^2$
（ASTM E331）	要求　持續 15 分鐘 不得有滲水現象
(六)動態水密性能測試	壓力差　720Pa，噴水量為 $4.0l/min/m^2$
（AAMA 501.1）	要求　持續 15 分鐘 不得有滲水現象
(七)結構性能測試	壓力差　+1375Pa（50%）；+2750Pa（100%）
（ASTM E330）	要求　-2355Pa（50%）；-4710Pa（100%

		除防水膠條外，所有材料不可有損壞故障，或容許之永久變形及位移量可為其淨跨距之 0.2%。
(八)側向位移	位移量	±10mm（各三循環）
（第一階段）	要求	所有測試材料不得有損壞，故障及永久變形，移位之情形。
(九)活動開窗 30 次		
(十)靜態水密性能測試	壓力差	如同第 5 項
（ASTM E330）	要求	持續 15 分鐘 不得有滲水現象
(十一)超結構性能測試	壓力差	+2065Pa（75%）；+4125Pa（150%）
（ASTM E330）	要求	-3535Pa（75%）；-7065Pa（150%） 破壞性試驗，僅供參考。
(十二)側向位移	位移量	±20mm（各三循環）
（第二階段）	要求	破壞性試驗，僅供參考。

五、風雨試驗測試體說明

本試體係依據本工程規範規定，試體尺寸應為二層樓高，四個直料三跨距寬，應包括開窗部。

(一)測試體尺寸：3.58m(寬),x8.9m(高)2 面支撐結構的玻璃系統。

開窗尺寸：1.2m(寬)x1.9m(高)－－－－－－2 樘

鋁板尺寸：1740Tnm(寬)x835mm(高)－－－－－-9 片

(二)玻　　璃：本試體玻璃係採用元璋玻璃股份有限公司所提供之 8mmF.GR-H.S GLASS+6mmAir Space Filled With Argon+8mm Clear Float Glass-H.S 熱硬化複層玻璃,並檢附 CNS 檢驗標準及 CNS 正字標記證書。

玻璃尺寸：1752mm(寬)x855mm(高)-18 片

1652mm(寬)x789mm(高)－ 2 片

(三)結構性矽膠：本試體係採用台灣道康寧股份有限公司所提供之一液型結構性矽膠,型號 DC-795,並檢附報告。

防水填縫劑：本試體係採用台灣道康寧股份有限公司所提供之防水填縫劑,型號 DC-791,並檢附檢驗報告。

(四)試體按裝程序及日期：

一按裝測試樣品鋁直料及鋁橫斜：3 月 17 日共計 4 日。

一按　　裝　　鋁　　板：3 月 21 日共計 2 日。

一按裝玻璃及充填防水填縫劑　：3 月 25 日共計 3 日。

(五)試體電訊測試點之按裝及說明：

在測試過程中,在每段風壓力所造之之撓曲程度,皆記錄在藉由測試樣品之鋁直料、鋁橫料及鋁板上之電訊測試點轉換在相連之電腦上,並作成記錄,本試體共按裝 10 個電訊測試點如 Figl 分別為：

一鋁直料編號 NO.0~NO.3

一鋁橫斜編號 NO.4~NO.6

一鋁板編號 NO.7~NO.9

六、測試過程及說明：

有關本風雨試驗各項測試係按本工程之施工規範以及美國材料測試協會(ASTM)所規定之測試法,利用新加坡 Winwall 公司提供之風雨試驗測試場所及設備所進行各項測試。

(一)測試時間：2003 年 3 月 28、29 日

(二)測試前之簡報會議：

由參與本次風雨試驗之各單位檢測人員,於測試場之會議室,聽取所做之簡報,介紹有關本次測試試體模型之說明及按裝過程、和試體本身與測試場各週邊設備之相關位置,並對測試中所使用之各項機具設備、測試儀器(如壓力計、油水機、鼓風機、氣流測試器、噴水設備等)逐一介紹,並指導在場參與檢測人員,如何判讀電腦儀表上所出現之數據及曲線表,與會人員並在其引導下,對整個測試場實地參觀,並對試體所使用之各項材料及規格,進行檢驗核對，是否符合本工程規範所規定之材質,經與會人員檢驗均符合規定後,正式進入測試作業。

(三)預先檢查承載力之測試：

此項測試最主要是為了在做主測試前檢查按裝在測試室之試體狀況，測試時，先在試體施加1375pa風壓力(50%之正風壓)，一分鐘後再回復無壓力(0Kg/m^2)的狀況下按測其預負載，並以目測方式，檢查試體是否有損壞現象。

(四)氣密性能之測試：

按本工程施工規範及 ASTM-E283 之規定，在室內外壓力差 75pa 之壓力下；用來計算測試室內外空氣流動率。以風速計測量 VENTURI TUBE 內之空氣流動速度。

(五)活動開窗 30 次

(六)靜態水密性測試：

按本工程施工規範及 ASTM E-331 之規定，測試室中用穩定之風壓，以每分鐘四公升之水量噴向試體之開窗部，其最大壓力應為 720pa，並就此壓力噴水於開窗部表面上十五分鐘，再以肉眼按視模型背面有無漏水的情況。

(七)動態水密性測試：

按本工程施工規範及 AAMA 501.1 之規定，測試室中用穩定之風壓，以每分鐘四公升之水量噴向試體之固定部份，其最大壓力應為 720pa，並就此壓力噴水於固定部表面上十五分鐘，再以肉眼檢視模型背面有無漏水的情況。

(八)結構性能測試：

按本工程施工規範及 ASTM E-330 之規定，測試樣品之鋁直料、鋁橫料以及鋁板上，在逐步施加下列之壓力之情況下：正風壓：1375pa(50%

設計風壓)、 2065 pa(75%設計風壓)、 2750pa(100%設計風壓)以及負風壓:-2355pa(50%設計負風壓)、-3535 pa(75%設計負風壓)、-4710pa(100%設計負風壓)、5101pa。

在上述每段風壓力所造成之撓曲程度,皆記錄在藉由測試樣品之鋁直料、鋁橫料及鋁板上之電測訊號轉換在相連之電腦上。

註:本帷幕牆設計之風壓力為:

正風壓 280g/㎡(2750pa)

負風壓 480g/㎡(4710pa)

但經參與檢測人員會議討論,決定將風壓提高為:

正風壓 280Kg/m^2 (2750pa)

負風壓 520Kg/㎡(5101pa)

(九)側向位移 (第一階段)

位移量 ±10mm (各三循環)

要求所有測試材料不得有損壞,故障及永久變形,移位之情形。

其每階段所產生的撓度程度皆記錄在與測試樣品之鋁直料、鋁橫料及鋁板上之電測訊號轉換在相連之電腦上。

為查核殘留之撓度,將壓力降至0,後再查看電腦記錄,若該測試樣品之鋁直料、銘橫料及鋁板有因測試而導致撓度受損,則可由記錄器上查知。

(十)活動開窗 30 次。

(十一)第二次靜態水密性測試:

在經過抗風壓力之測試後,試體之鋁直料、鋁橫料及鋁板所產生之撓曲變化,當回復無壓力(0Kg/m^2)狀態後,再以每分鐘四公升之水量噴向試體,其最大壓力應為 720pa，時間十五分鐘,再以肉眼檢視模型背面有無漏水的情況。

(十二)超結構性能測試：破壞性試驗，僅供參考

按 ASTM E-330 標準及本工程施工規範要求,增加 1.5 倍設計抗風壓力之測試樣品之鋁直料、鋁橫料以及鋁板等，逐步施加至下列之壓力：2065pa(75%設計正風壓)、4125pa(150%設計正風壓)、-3535pa(75%設計負風壓)、-7065 pa(150%設計負風壓)。

其每階段所產生的撓度程度皆記錄在與測試樣品之鋁直料、鋁橫料及鋁板上之電測訊號轉換在相連之電腦上。

為查核殘留之撓度，將壓力降至 0，後再查看電腦記錄，若該測試樣品之鋁直料、銘橫料及鋁板有因測試而導致撓度受損，則可由記錄器上查知。

(十三)側向位移(第二階段): 破壞性試驗，僅供參考。

位移量 ±20mm（各三循環）

其每階段所產生的撓度程度皆記錄在與測試樣品之鋁直料、鋁橫料及鋁板上之電測訊號轉換在相連之電腦上。

為查核殘留之撓度，將壓力降至 0，後再查看電腦記錄，若該測試樣品之鋁直料、銘橫料及鋁板有因測試而導致撓度受損，則可由記錄器上查知。

七.風雨試驗測試結果

項　　目	設計規範	試驗結果	(英文版)試驗報告頁數
氣密性試驗	測試壓力 75Pa 固定部分 小於 0.0182M^3/min (1.092M^3/hr)	0.78M^3/hr	P-12 (5.3)
	開窗部分 小於 0.0232M^3/min (1.392M^3/hr)	0.78M^3/hr	P-12 (5.3)
水密性試驗 靜態水密性	測試壓力 720Pa 水量 4L/Sq M/Min 15 分鐘不得滲水	無滲水	P-12 (5.4) P-14 (5.9)
動態水密性		無滲水	P-13 (5.5)
風壓結構試驗 風壓 280kg/M^2 (2750 Pa)	結構無損壞 容許變形量 L/175 或 20mm	變形量 2.74mm	P-13 (5.6)
風壓 480kg/M^2 (4710 Pa)		變形量 -5.2mm	p-13 (5.6)
層間位移	20mm 結構無損壞	結構無損壞	P-14 (5.8) P-15 (5.11)

八、結論與建議

(一)結論

本帷幕牆風雨試驗測試結果，各試驗項目皆符合設計規範規定值，未來實際施工時，只要確實按測試試體之施工詳圖監督施工，應能確保工程品質。

(二)建議

1. 國內規範的制定

國內興建高層大樓的業紝，為了確保外牆品質都體送國作風雨試驗，雖然國內有協樺、中國力霸兩家公司擁有風雨實驗室，但是缺乏相關法規強制執行驗證，以及取得相關的認證，並且不能一昧的抄襲國外法規(AAMA、ASTM)，建議發展出一套適合台灣試驗規範。

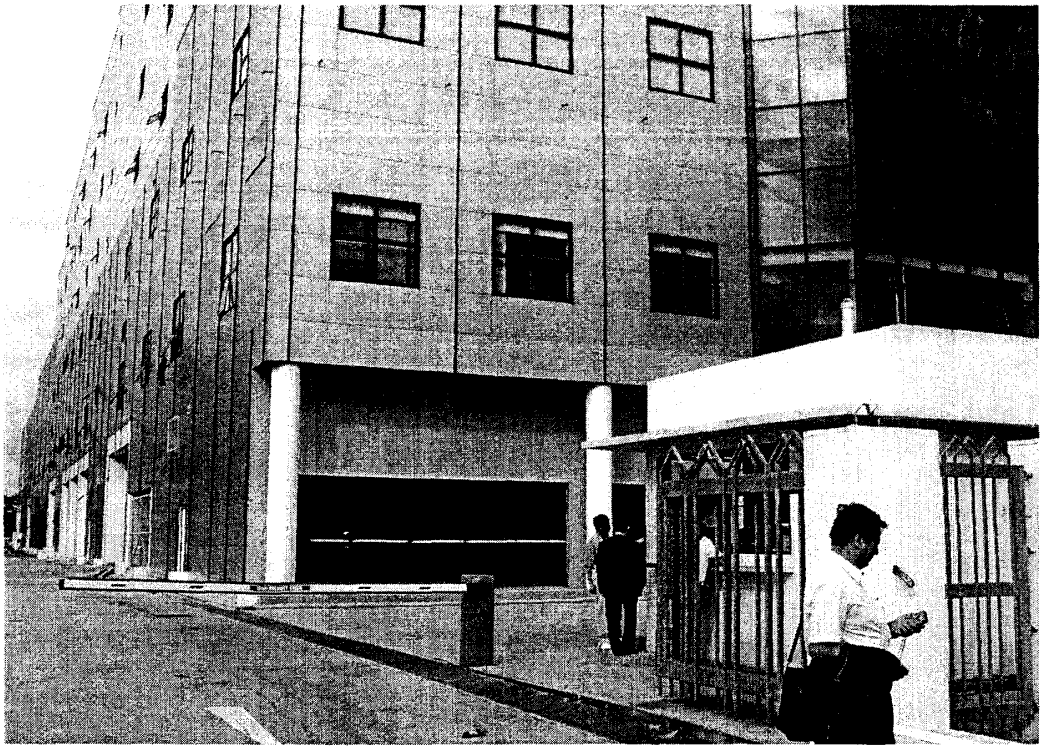
2. 針對動態水密試驗時所用造風器之建議

因國內引擎取得不易，且維修、保養上的考量，建議使用其他的方式可以達到所需的風力即可。

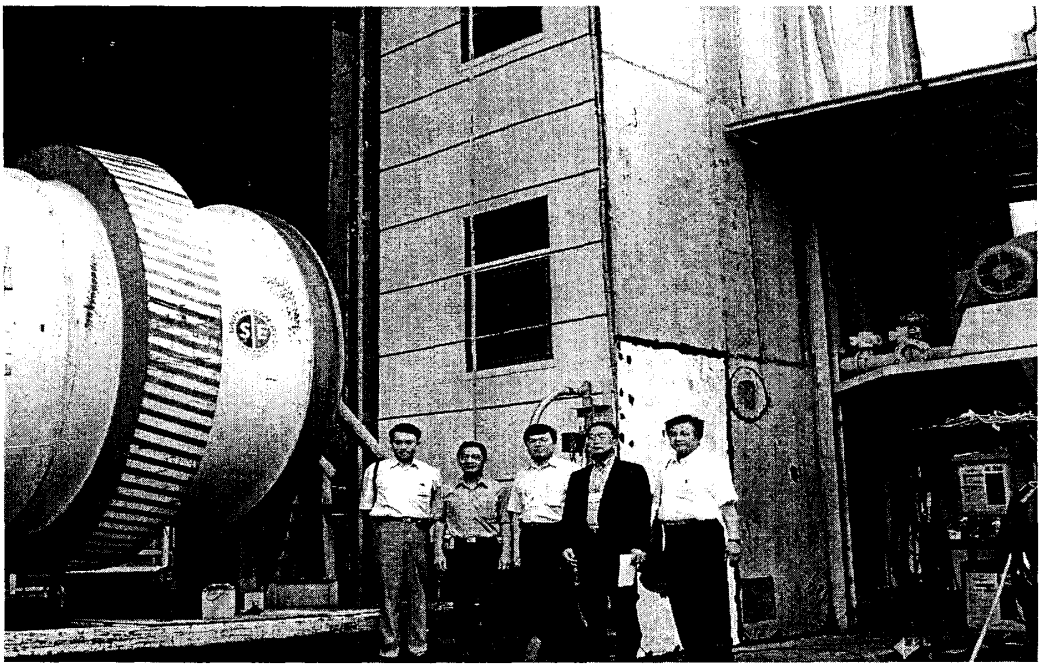
3. 實驗室成立後對人員的訓練及認證，應該明確規定。

4. 國內風雨實驗館之 CNLA 認證

CNLA 是以一套認證程序，對校正或測試之軍公民營實驗室具有執行特定校正或測試的能力、予以公開正式承認。是以符合 ISO/IEC 17025(1999)的認證規範與符合 ISO/IEC Guide 58 的認證條件為基礎。其公開承認的力式是以認可證書頒發與認可實驗室名錄的登錄為主。建議未來符合 CNLA 認證要求的實驗室，能夠對外開放給國內業者做檢測使用，以協助工業升級，以節省國家資源。



帷幕牆風雨試驗測試公司入口大門



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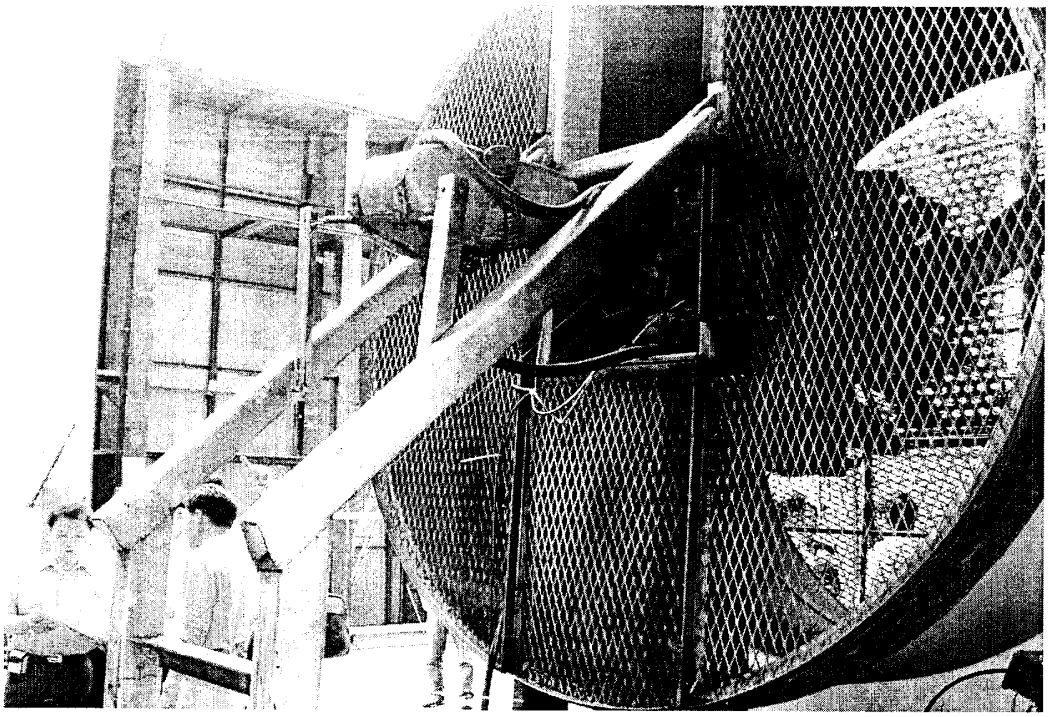

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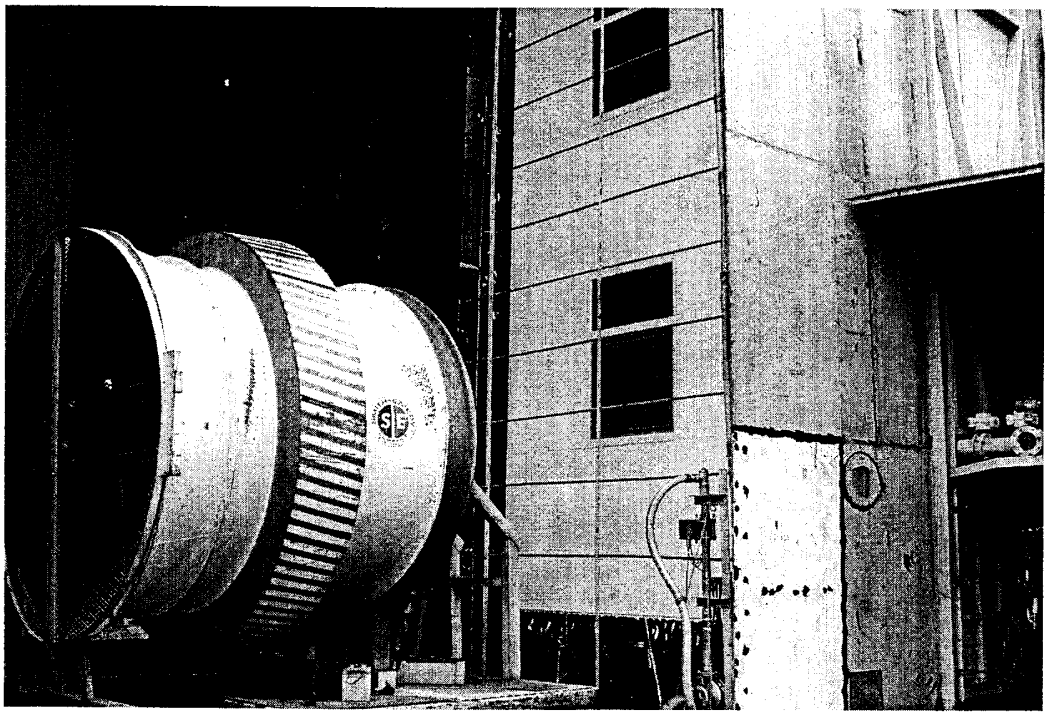

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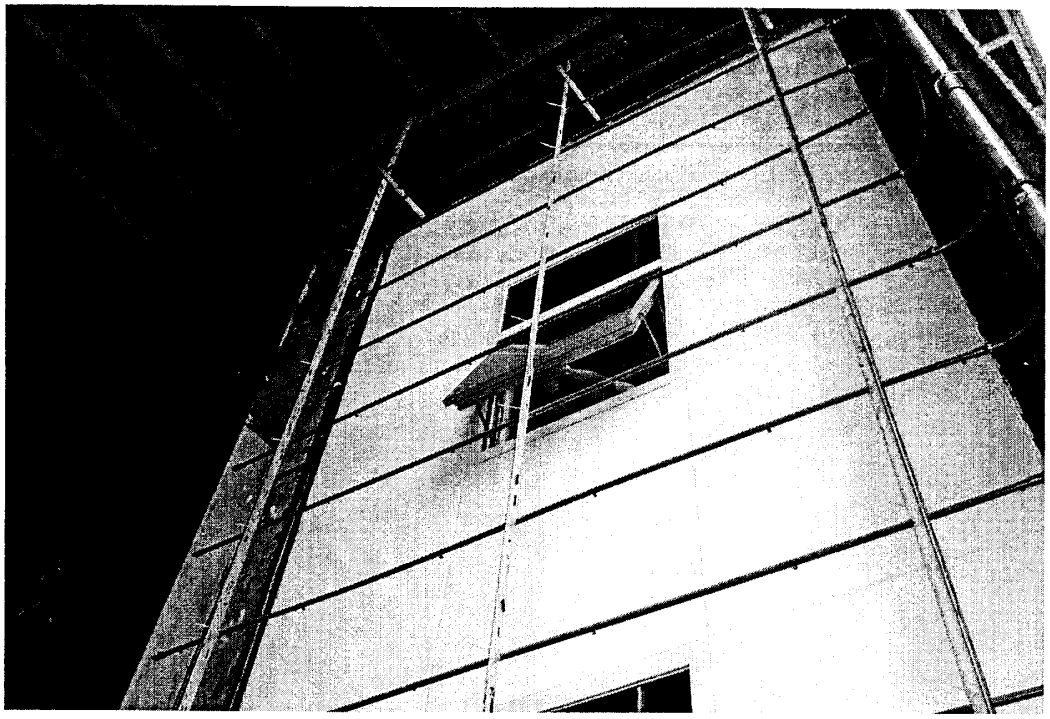

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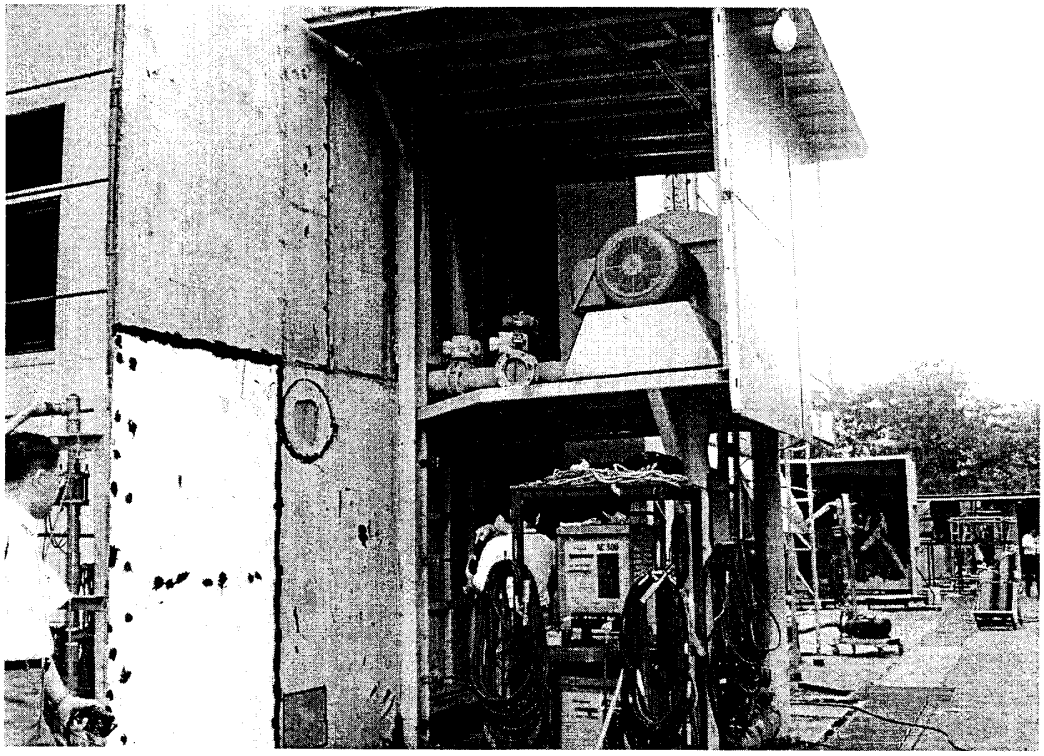

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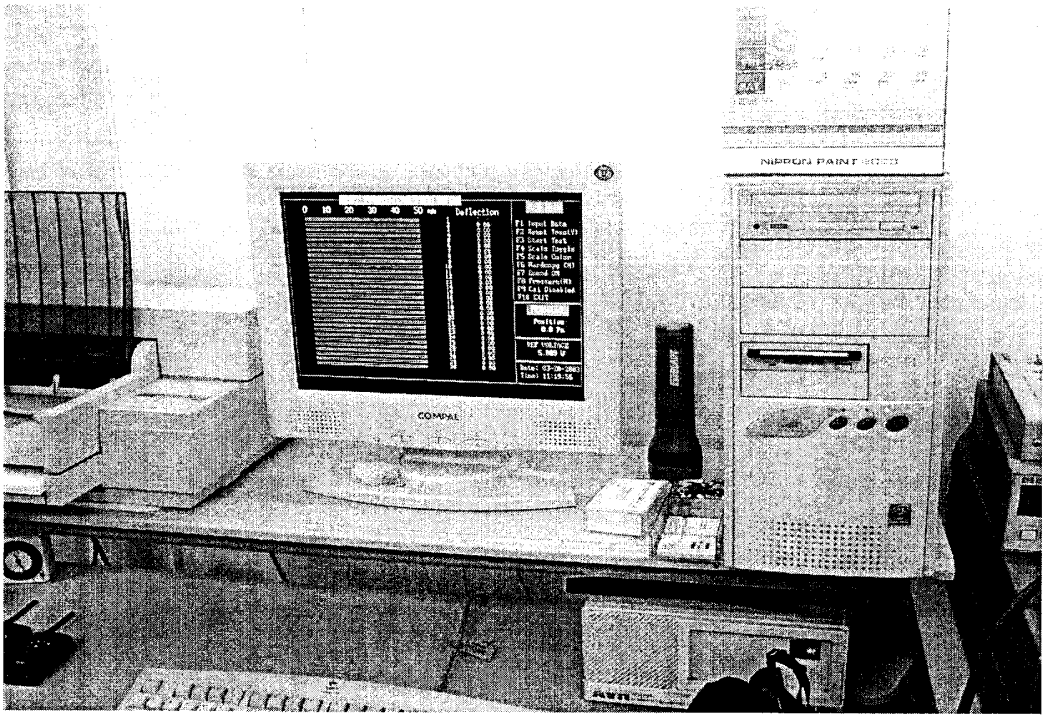
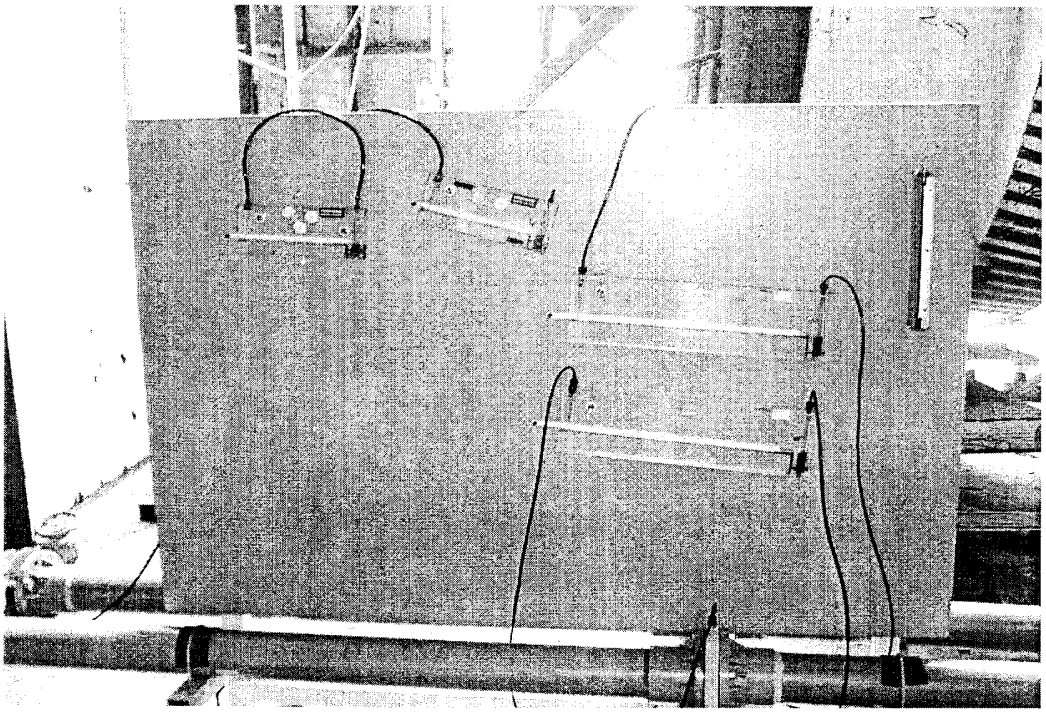


電腦顯示「風壓記錄表」



氣密性能測量計

REPORT

DUPLICATE

r Ref:

Date: 1 April 2003

Ref: W 0546/TR

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E: This Report is issued subject to the terms and conditions set out overleaf.

Performance test of curtain wall system for

國立臺灣科技大學第五綜合實習工廠新建工程

TESTED FOR:

Tong Shin Aluminium Corporation
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ACCREDITED LABORATORY
SAC-SINGLAS
CERT. NO : LA-1996-0101-B

國立台灣科技大學第五綜合實習工廠新建工程

風雨試驗測試報告與設計規範比照表

項　　目	設計規範	試驗結果	試驗報告頁數
氣密性試驗	測試壓力 75Pa 固定部分 小於 0.0182M^3/min (1.092M^3/hr)	0.78M^3/hr	P-12 （5.3）
	開窗部分 小於 0.0232M^3/min (1.392M^3/hr)	0.78M^3/hr	P-12 （5.3）
水密性試驗 A.靜態水密性	測試壓力 720Pa	無滲水	P-12 （5.4） P-14 （5.9）
B.動態水密性	水量 4L/Sq M/Min 15分鐘不得滲水	無滲水	P-13 （5.5）
正負風壓結構試驗 A.正風壓 280kg/M^2 （2750 Pa）	結構無損壞 容許變形量 L/175 或 20mm	變形量　2.74mm	P-13 （5.6）
B.負風壓 480kg/M^2 （4710 Pa）		變形量　-5.2mm	P-13 （5.6）
層間位移	20mm 結構無損壞	結構無損壞	P-14 （5.8） P-15 （5.11）

CONTENT

1. INTRODUCTION

Winwall was engaged by Tong Shin Aluminium Corporation (hereinafter call `the company) of address: 166, Yin Lin Road Jente Hsiang, Tainan Hsien, Taiwan R.O.C. to conduct performance test of one curtain wall specimen for 國立臺灣科技大學第五綜合實習工廠 新建工程.
Performance test on the specimen was conducted on 28 March 2003.

The following tests were conducted:

(a) Preliminary loading (positive pressure).
(b) Open, close and lock windows for 30 times.
(c) Air infiltration test – ASTM E283-91*.
(d) Static water penetration test - ASTM E331-00.
(e) Dynamic water penetration test - AAMA 501.1-94*.
(f) Structural performance test - ASTM E330-97.
(g) Lateral movement test (± 10 mm)*.
(h) Open, close and lock windows for 30 times.
(i) Static water penetration test - ASTM E331-00.
(j) Structural proof load test - ASTM E330-97.
(k) Lateral movement test (± 20 mm)*.

Remark '*' : Not SAC-Singlas accredited

2. TEST FACILITY

The testing facility consists of the following:

2.1 A steel test chamber of dimensions 6-m (W) x 13-m (H).

2.2 HEWLETT PACKARD VX1 data acquisition system.

2.3 27 numbers of 50 mm range and 3 numbers in 150 mm range PIODEN displacement transducers.

2.4 LECHLER full cone nozzles (700 mm centre to centre).

2.5 Two CROSSLE centrifugal blowers of 10 pa at 4000 CFM capacities.

2.6 ROSEMOUNT pressure transmitter (Calibration range -10 kPa to 10 kPa).

2.7 AIRFLOW manometers (Range : -0.125 kPa to 0.125 kPa, -0.5kPa to 0.5 kPa, -2.0 kPa to 2.0 kPa, -9.0 kPa to 9.0 kPa).

2.8 PODDYMETER orifice plate air flowmeters.

2.9 WORTHINGTON water pump with 25 HP motor.

2.10 OMERON PLC system.

2.11 KINERTROL rotary actuator with positioner and I/P controller.

2.12 50 tons ENERPAC double acting hydraulic ram with control system.

2.13 Aircraft Engine Propeller.

3. TEST SPECIMEN

The stick system curtain wall test specimen has an overall frontal dimension of 3.58m wide by 8.9m high consisted of aluminium mullions and transoms skeleton, aluminium cladding, fixed windows and two operable windows.
The general view of the test specimen is shown in Photo 1. The overall dimension and the construction details of the specimen are shown in the company ' s drawings attached.

The specimen was constructed such that the interior face of the test specimen was fitted in the pressure chamber. The remaining area was sealed with plywood to form an airtight chamber. A water spray rack system was used to wet the entire test specimen during water penetration test. Electronic displacement transducers were mounted onto the selected components to monitor the movement of the specimen under design load. One double acting hydraulic cylinder was mounted on the middle steel I-beam to facilitate the lateral movement test. Electronic displacement transducers were used to monitor the movement of the middle I-beam. An aircraft engine propeller was used to generate airflow acting onto the exterior face of the specimen during the dynamic water penetration test.

Photo 2 shows a view of the type of bracket used for installation of the test specimen.

4. METHODS, SEQUENCE AND REQUIREMENTS OF TESTS

The following items were the sequence and methods of the tests conducted on the curtain wall specimen as requested by the company. The company submitted the requirements of the test conducted. The sequence of the tests was as follows:

(a) Preliminary loading (positive pressure).
(b) Open, close and lock windows for 30 times.
(c) Air infiltration test – ASTM E283-91.
(d) Static water penetration test - ASTM E331-00.
(e) Dynamic water penetration test - AAMA 501.1-94.
(f) Structural performance test - ASTM E330-97.
(g) Lateral movement test (± 10 mm).
(h) Open, close and lock windows for 30 times.
(i) Static water penetration test - ASTM E331-00.
(j) Structural proof load test - ASTM E330-97.
(k) Lateral movement test (± 20 mm).

4.1 PRELIMINARY LOADING (POSITIVE PRESSURE)

Prior to the testing, the specimen was preloaded to positive pressure of 1375 Pa (50% of positive design pressure of 2750 Pa) maintained for 10 seconds and then unloaded to zero pressure.

4.2 OPEN- CLOSE AND LOCK WINDOWS FOR 30 TIMES

Prior to the testing, The two operable windows were subjected to a repeated cycles of `open, close and lock'operation for 30 times to check its functionality.

4.3 AIR INFILTRATION TEST
ASTM E 283-91
Rate of air leakage through exterior windows, curtain walls and doors.

As specified by the company, the test pressure applied onto the test specimen was positive 75 Pa.

Refer to figure F.1 for schematic drawing for air infiltration test set-up.

Procedure :

a. The exterior face of the entire specimen was first covered with PE sheet. The opening joint perimeter of the operable windows was sealed with masking tape at the interior face of the specimen.
b. The chamber was pressurised gradually by a blower to the required test pressure of 75 Pa, read from the manometer. The air leakage of the chamber expressed in m^3/hr (read from the air flow meter) at 75 Pa was recorded as q_1.
c. The PE sheet was then removed from the specimen (windows remained sealed) and procedure (b) was repeated.
d. The second air leakage reading taken from the air flow meter was the air leakage through the chamber and the test specimen fixed areas. This reading was recorded as q_2.
e. The masking tape was then removed from the windows. Procedure (b) was repeated. The air leakage taken was the air leakage through the chamber, the test specimen fixed areas and the operable windows. This reading was recorded as q_3.
f. The actual air leakage of the specimen fixed area, Q_1, is equal to $q_2 - q_1$.
g. The actual air leakage through the operable windows, Q_2, is equal to $q_3 - q_2$.
h. The air infiltration of the test specimen fixed area, Q_{fw}, in term of unit area, is calculated as actual air leakage through the fixed area divided by the total frontal fixed areas of the specimen (A_f). $Q_{fw} = Q_1 / A_f$.
i. The air infiltration of the operable windows, Q_w, in term of unit length, is calculated as actual air leakage through the operable windows divided by the total opening joint perimeter of the windows (L_w). $Q_w = Q_2 / L_w$.

Requirement : i) Air infiltration shall not exceed 1.092 m^3/hr per metre square for fixed area.
ii) Air infiltration shall not exceed 1.392 m^3/hr per meter length for operable window.

Remark: If the total air leakage of the chamber and specimen fixed area is less than the allowable air leakage of the specimen alone. The procedure of sealing the specimen using PE sheet shall be omitted.

4.4 STATIC WATER PENETRATION TEST

ASTM E 331-96
Water penetration of exterior windows, curtain walls and doors by uniform static air pressure difference.

As specified by the company, the test pressure applied onto the test specimen was positive 720 Pa.

Refer to figure F.2 for schematic drawing for water penetration test set-up.

Procedure:

a. Water was sprayed from an array of nozzles spaced 700 mm centre to centre and approximately 400 mm from the curtain wall specimen surface at a rate of approximately 4 litre/min/m^2.
b. The test chamber was then pressurized gradually to the required pressure of 720 Pa maintained for 15 minutes.
c. Water was sprayed continuously during the duration of the test.
d. The test specimen was visually checked for water leakage during the duration of the test.

Requirement : There shall be no uncontrollable water leakage during the duration of the test. Uncontrollable water leakage is defined as :-

a. Water appears on the inside face of the specimen and is visible from an occupied space.

b. Water appears on the inside face of the specimen and is likely to damage insulation or architectural fixtures.

c. Water leakage that is not contained and drained away within the test period.

4.5 DYNAMIC WATER PENETRATION TEST

AAMA 501.1-94
Standard test method for metal curtain walls for water penetration using dynamic pressure.

As specified by the company, the test pressure applied onto the test specimen was positive 720 Pa.

Refer to figure F.2 for schematic drawing for water penetration test set-up.

Procedure :

a. Water was sprayed from an array of nozzles spaced 700 mm centre to centre and approximately 400 mm above the curtain wall surface at a rate of approximately 4 litre/min/m^2.

b. Airflow was generated by an aircraft engine propeller to produce the equivalent air pressure of 720 Pa acting on the exterior face of the specimen.

c. Water was sprayed continuously for 15 minutes.

d. The test specimen was visually checked for water leakage at the interior side of the specimen during the duration of the test.

Requirement : There shall be no uncontrollable water leakage during the duration of the test. Uncontrollable water leakage is defined as :-

a. Water appears on the inside face of the specimen and is visible from an occupied space.

b. Water appears on the inside face of the specimen and is likely to damage insulation or architectural fixtures.

c. Water leakage that is not contained and drained away within the test period.

4.6 STRUCTURAL PERFORMANCE TEST

ASTM E 330-97
Structural performance of exterior windows, curtain walls and doors by uniform static air pressure difference.

As specified by the company, the test pressures applied onto the test specimen were positive 2750 Pa and negative -4710 Pa.

Refer to figure F.3 for schematic drawing for structural performance test set-up.

Procedure :

a. Seven (7) numbers of displacement transducers were mounted on the test specimen to measure the displacement of the test specimen. Each transducer was checked prior to testing.

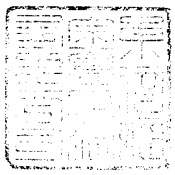
b. The test specimen was preload to 50% of the positive design load for 10 seconds and then unloaded to zero pressure.

c. The test specimen was then loaded to 100% of the positive design load (2750 Pa) with increments indicated in figure F.4 and at each increment, the displacement of the test specimen was captured by a HP data acquisition system and the displacement values were calculated by a in-house software and then shown on the computer monitor and printed out.

d. The pressure was then unloaded to zero pressure and the residual deformations were measured two minutes later.

e. The procedure (b) to (d) were repeated for negative pressure of -4710 Pa.

Requirement: Deflection of structural member shall not exceed L/175 (L = span) or 20 mm whichever is less.
Residual deflection shall not exceed 0.2% of clear span.



4.7 LATERAL MOVEMENT TEST (FIRST PHASE)

The lateral movement test was conducted in such a way that the middle I- beam was displaced laterally by hydraulic cylinders to the required distance of ± 10 mm for 3 cycles. The movement was measured with respected to its original position.

The top and bottom I-beams were fixed during the test. The chamber I-beams were simulates concrete floor slabs.

Refer to F.5 for schematic drawing for lateral movement test set-up.

Requirement: There shall be no failure of glass pane or permanent distortion of bracket, hardware, framing and panels. There shall be no failure of sealant.

4.8 OPEN- CLOSE AND LOCK WINDOWS FOR 30 TIMES

The two operable windows were again subjected to a repeated cycles of `open, close and lock ' operation for 30 times to check its functionality.

4.9 STATIC WATER PENETRATION TEST

Same procedure and requirement as in Section 4.4.

4.10 STRUCTURAL PROOF LOAD TEST

Prior to the test, the test specimen was preloaded to 2065 Pa (75% of the positive design pressure) for 10 seconds and then unloaded to zero pressure. The test specimen was then gradually loaded to 2065 Pa for 10 seconds followed by 4125 Pa (150% of the positive design pressure) for 10 seconds before reduced to zero pressure.

Similar procedure was repeated for negative proof load test. The negative pressures applied onto the specimen were –3535 Pa (75% of the negative design pressure) and –7065 Pa (150% of the negative design pressure).

Requirement: There shall be no structural failure. There shall be no failure of glass pane or permanent distortion of bracket, hardware, framing and panels.

4.11 LATERAL MOVEMENT TEST (SECOND PHASE)

Same procedure and requirement as in Section 4.7 but the lateral movement was increased to ± 20 mm for 3 cycles.

Requirement: Same requirement as in Section 4.7 but disengagement of glazing gasket and failure of weather proofing gasket is allowed.

5. SUMMARY OF TEST RESULTS:

5.1 PRELIMINARY LOADING (POSITIVE PRESSURE)

Prior to the testing, the specimen was loaded to 1375 maintained for 10 seconds and then unloaded to zero pressure.

5.2 OPEN -CLOSE AND LOCK WINDOWS FOR 30 TIMES

No functional fault of hardware was noted on the two operable windows after each of the window was subjected to the repeated cycles of open, close and lock operation for 30 times.

5.3 AIR INFILTRATION TEST

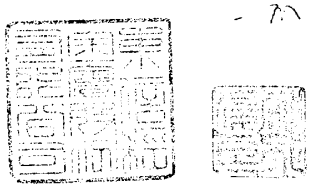
Test	Test pressure	Company's Requirement
	75 Pa	
Air infiltration of the curtain wall fixed area. (m^3/hr. m^2)	0.78	1.092 m^3/hr. m^2 maximum
Air infiltration of the operable window. (m^3/hr. m)	0	1.392 m^3/hr. m maximum

Note: Refer to Appendix A.1 for detail results of the air infiltration test.

5.4 STATIC WATER PENETRATION TEST

Test pressure (Pa)	Time maintained (mins)	Observation
720	15	No water leakage was observed from the specimen throughout the test duration.

Photo 3 shows a partial view of the specimen undergoing water penetration test.



5.5 DYNAMIC WATER PENETRATION TEST

Test pressure (Pa)	Time maintained (mins)	Observation
720	15	No water leakage was observed from the specimen throughout the test duration.

5.6 STRUCTURAL PERFORMANCE TEST

Location of components measured (Transducer no.)	Test Pressure:		Requirement: Deflection of structural member shall not exceed span/175 or 20 mm whichever is less.
	2750	-4710	
Deflection (mm) of aluminium mullion: (7) - (4 + 10)/2	2.74	-5.2	17.1 mm maximum. (span = 3000 mm)

NOTE:
a. Refer to Appendix A.2 and A.3 for detail results of displacement readings.
b. Refer to figure F.6 for locations of displacement transducers measurements on test specimen.
c. Deflection of aluminium structural member and other component is calculated based on measured value minus the average of the corresponding two end deflections.
d. No conclusions of any kind regarding the adequacy or inadequacy of the glass in the test specimen are to be drawn from the test.

Photo 4 shows a partial view of the displacement transducers mounted on the specimen for the structural test.

5.7 LATERAL MOVEMENT TEST (FIRST PHASE)

No collapse of specimen, no visible permanent distortion of brackets, no breakage of glass pane, no failure of other component was observed after the lateral movement of ± 10 mm for 3 cycles.

Photo 5 shows a view of the hydraulic cylinder mounted on the middle I-beam for lateral movement test.

5.8 OPEN -CLOSE AND LOCK WINDOWS FOR 30 TIMES

No functional fault of hardware was noted on the two operable windows after each of the window was subjected to the repeated cycles of open, close and lock operation for 30 times.

5.9 STATIC WATER PENETRATION TEST

Test pressure (Pa)	Time maintained (mins)	Observation
720	15	No water leakage from the specimen was observed during the test duration:

5.10 STRUCTURAL PROOF LOAD TEST

The test specimen withstood the positive pressure of +4125 Pa maintained for 10 seconds and negative pressure of -7065 Pa maintained for 10 seconds. No breakage of glass pane, no visible failure of component, no visible permanent deformation of bracket or failure of other component was observed after the test.

The displacement readings and residual readings were tabulated in Appendix A.4 and A.5 of the report.

5.11 LATERAL MOVEMENT TEST (SECOND PHASE)

No collapse of specimen, no visible permanent distortion of brackets, no breakage of glass pane, no failure of other component was observed after the lateral movement of ± 20 mm for 3 cycles.

Winwall

6. WITNESSES:

公司	姓名
國立台灣科技大學	沈進發
	李親民
	黃自寬 3/28
鍾紹明建築師事務所	蘇勝銘 92.3.28
	李建祥 3/28
德昌營造股份有限公司	
	簡慶豪 92.3.28
中信輕金屬股份公司	林良雄
	蔡璧楓
廣鈺五金企業有限公司	江毅晃

TESTED BY

GOH AIK WEE
ASSISTANT MANAGER

SIMON CHIN YUN FEN
DIRECTOR

APPENDIX A

A.1 AIR INFILTRATION TEST

Test Pressure (Pa)	75 Pa
Air leakage through chamber and curtain wall fixed area, q_2 (m^3/hr).	25*
Air leakage through chamber, curtain wall fixed area and windows, q_3 (m^3/hr).	25
Actual air leakage from the operable windows, Q_2 (m^3/hr).	0
Air infiltration of curtain wall fixed area, Q_{fw}. (m^3/hr.m^2).	0.78
Air infiltration of operable window, Q_w. (m^3/hr.m).	0

Total frontal fixed area of the specimen (A_f) is 31.86 m^2.
Total opening joint perimeter of the windows is 8.6 m.

Remark '*' : This is the total air leakage from the chamber and curtain wall fixed area. Air infiltration result calculated (0.78 m^3/hr.m^2) was smaller than the allowable air leakage limit (1.092 m^3/hr.m^2) of the specimen fixed area.

A.2 STRUCTURAL PERFORMANCE TEST (POSITIVE PRESSURE)

Locations of displacement transducers	Time maintained (secs)	Displacement (mm) of curtain wall specimen under positive pressure			
		Test pressure (Pa)			
		0	1375	2750	Residual deformation 2 minutes after the test pressure was removed
1	10	0	1.69	3.26	0.45
4		0	0.20	0.77	0.36
6		0	0.04	0.09	0.00
7		0	0.00	0.00	0.00
8		0	0.00	0.00	-0.04
9		0	-0.05	-0.08	-0.05
10		0	0.09	0.27	0.09

A.3 STRUCTURAL PERFORMANCE TEST (NEGATIVE PRESSURE)

Locations of displacement transducers	Time maintained (secs)	Displacement (mm) of curtain wall specimen under negative pressure			
		Test pressure (Pa)			
		0	-2355	-4710	Residual deformation 2 minutes after the test pressure was removed
1	10	0	-2.23	-6.25	-1.25
4		0	-0.40	-1.23	-0.41
6		0	-0.09	-0.27	0.00
7		0	-0.08	-0.24	-0.05
8		0	-0.10	-0.24	0.00
9		0	-0.05	-0.08	0.00
10		0	-0.18	-0.87	-0.28

See Figure F.6 for the locations of transducers on the specimen.

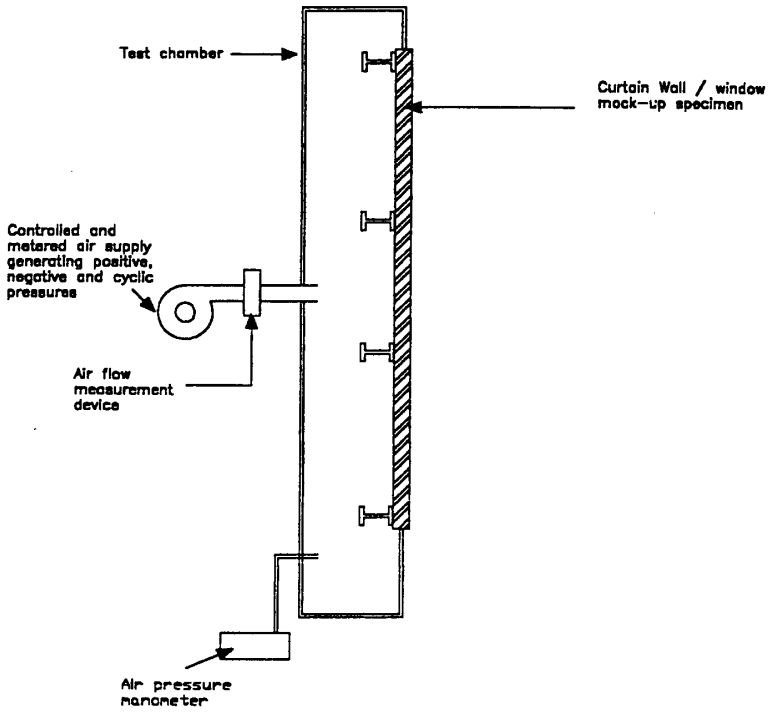
A.4 STRUCTURAL PROOF LOAD TEST (POSITIVE PRESSURE)

Locations of displacement transducers	Time maintained (secs)	Displacement (mm) of curtain wall specimen under positive pressure			
		Test pressure (Pa)			
		0	2065	4125	Residual deformation 2 minutes after the test pressure was removed
1	10	0	2.63	5.87	1.42
4		0	0.36	1.36	0.64
6		0	0.09	0.18	0.00
7		0	0.00	-0.11	-0.03
8		0	0.00	-0.10	-0.04
9		0	-0.03	-0.16	-0.08
10		0	0.13	0.50	0.18

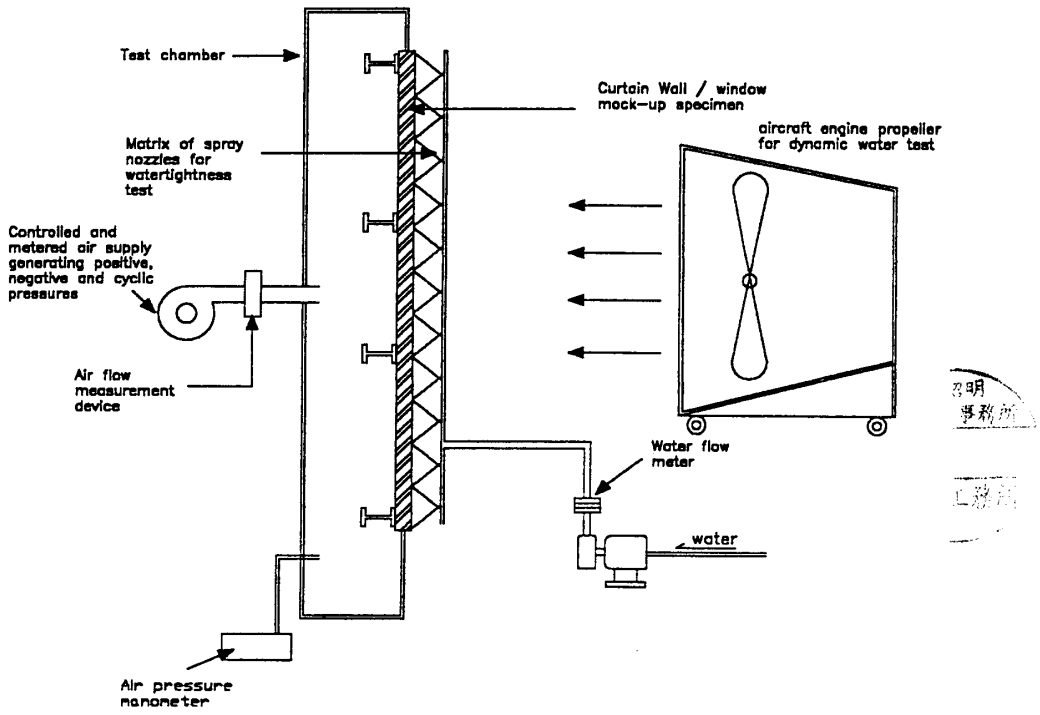
A.3 STRUCTURAL PERFORMANCE TEST (NEGATIVE PRESSURE)

Locations of displacement transducers	Time maintained (secs)	Displacement (mm) of curtain wall specimen under negative pressure			
		Test pressure (Pa)			
		0	-3535	-5100	-7065
1	10	0	-4.00	-6.32	-10.18
4		0	-0.67	-1.08	-2.04
6		0	-0.17	-0.35	-0.80
7		0	-0.12	-0.20	-0.37
8		0	-0.20	-0.28	-0.43
9		0	-0.08	-0.08	-0.13
10		0	-0.36	-0.86	-1.68

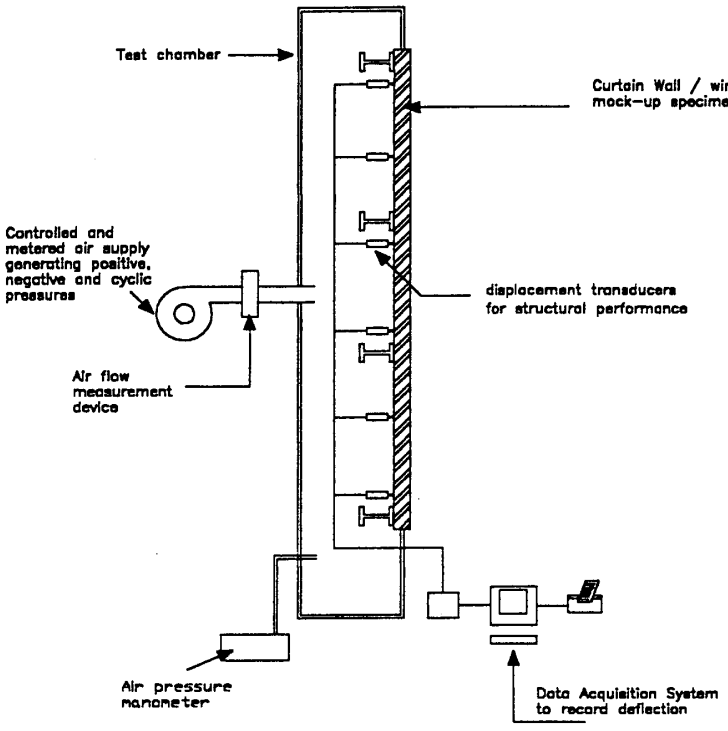
See Figure F.6 for the locations of transducers on the specimen.



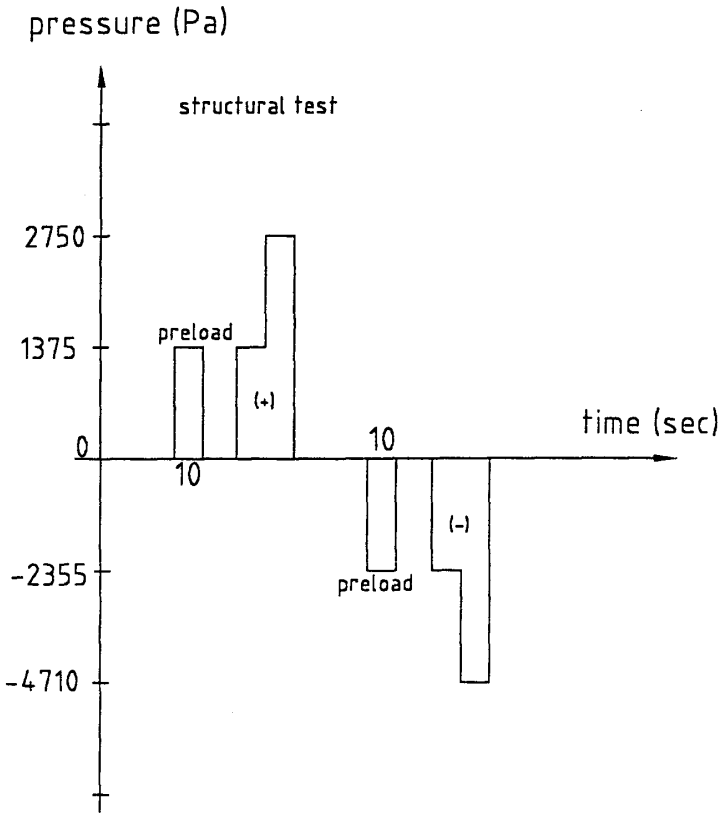
F.1 SCHEMATIC DRAWING FOR AIR INFILTRATION TEST SET-UP



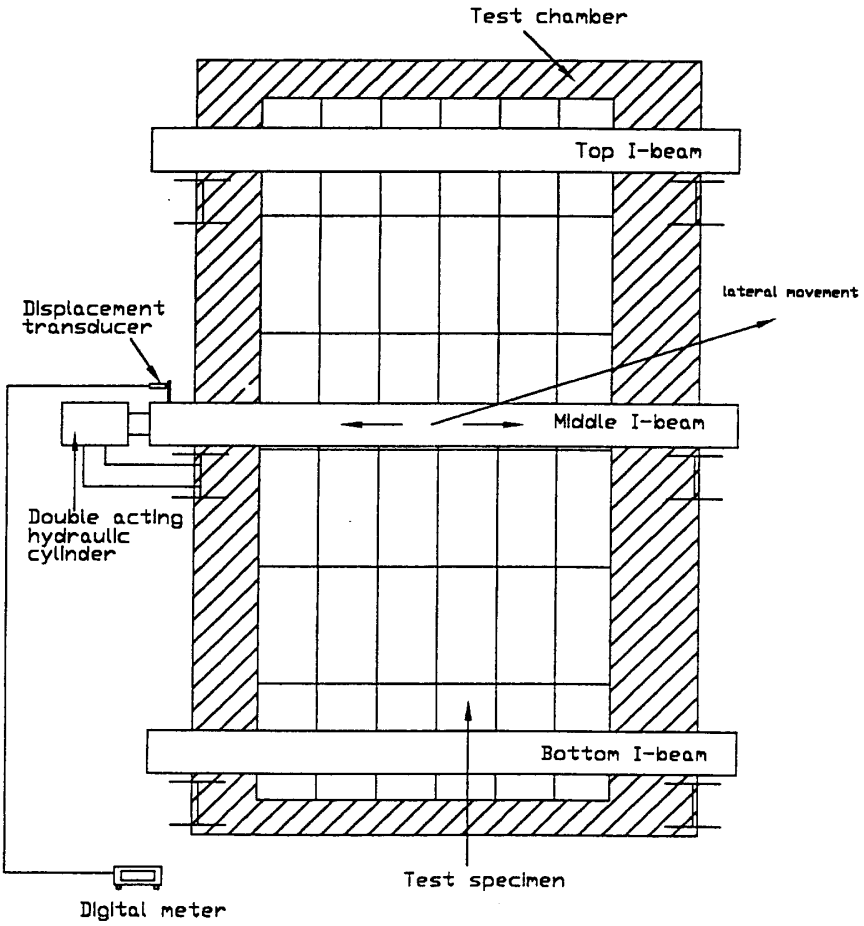
F.2 SCHEMATIC DRAWING FOR WATER PENETRATION TEST SET-UP



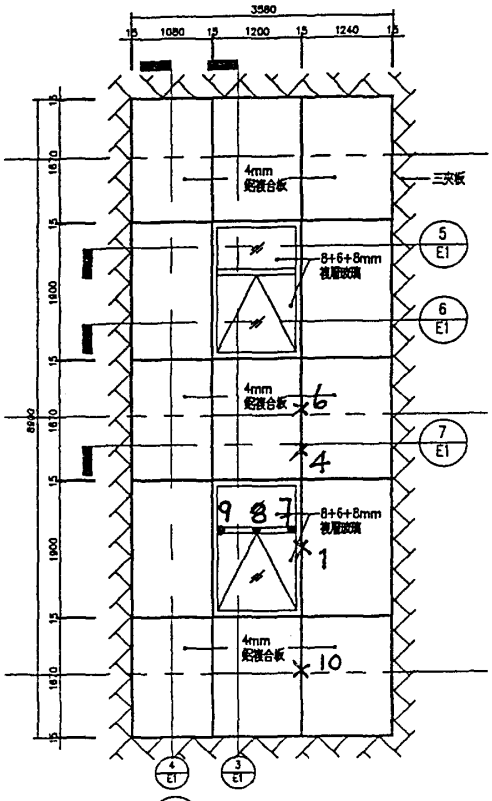
F.3 SCHEMATIC DRAWING FOR STRUCTURAL TEST SET-UP



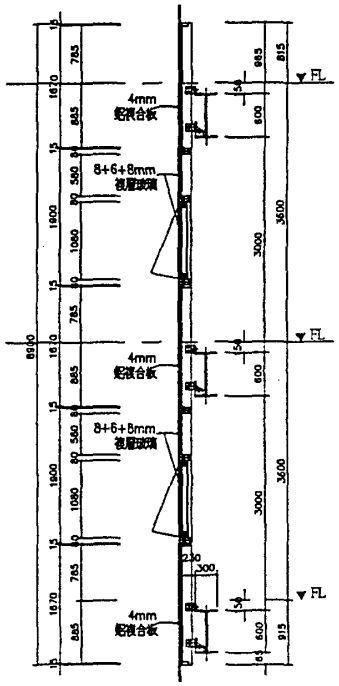
F.4 STRUCTURAL TEST AIR PRESSURE APPLICATION DIAGRAM



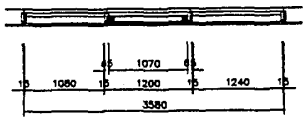
F.5 SCHEMATIC DRAWING FOR LATERAL MOVEMENT TEST



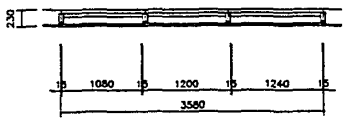
2 E1 立面圖 S:1/30



3 E1 立斷面圖 S:1/30



6 E1 平面圖 S:1/30



7 E1 平面圖 S:1/30

F.6 LOCATIONS OF DISPLACEMENT TRANSDUCERS ON TEST SPECIMEN.

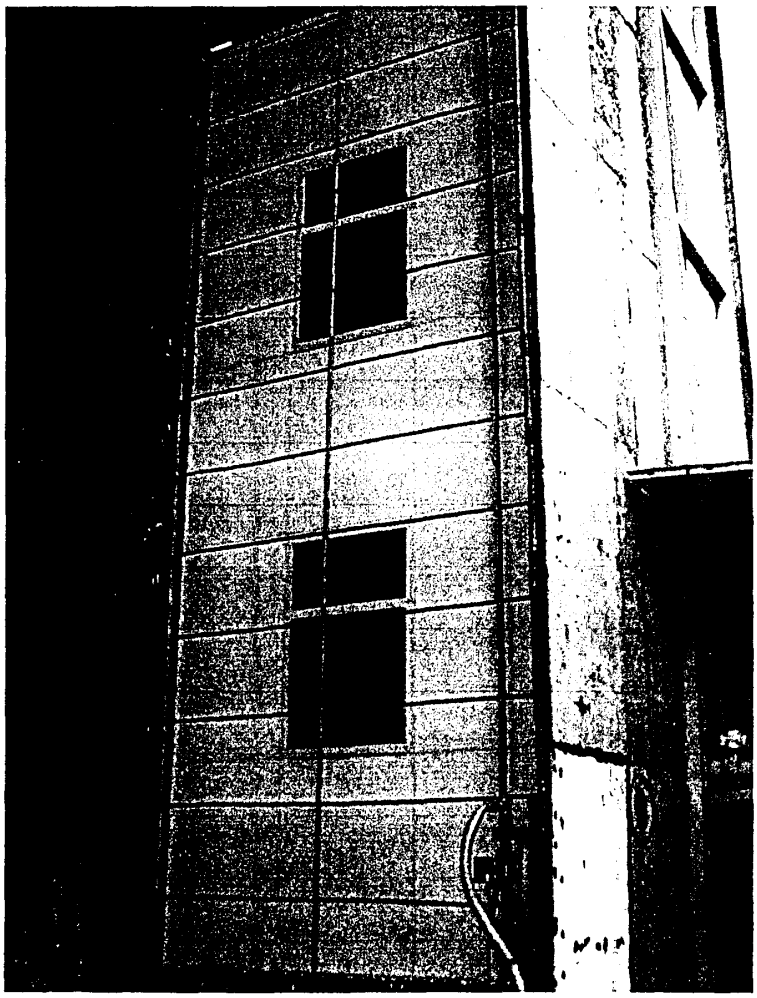


PHOTO 1. An exterior view of the test specimen.

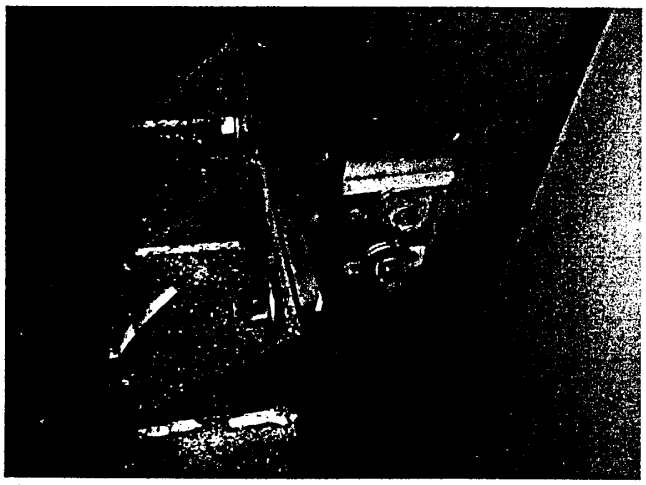


PHOTO 2. A view of the bracket used for installation of the specimen.

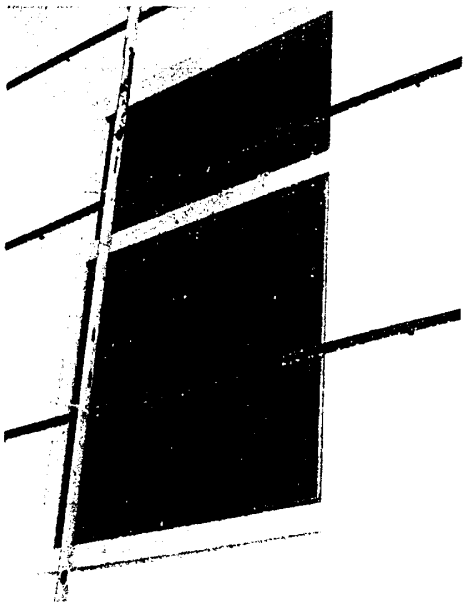


PHOTO 3. A view of the specimen undergoing water penetration test.

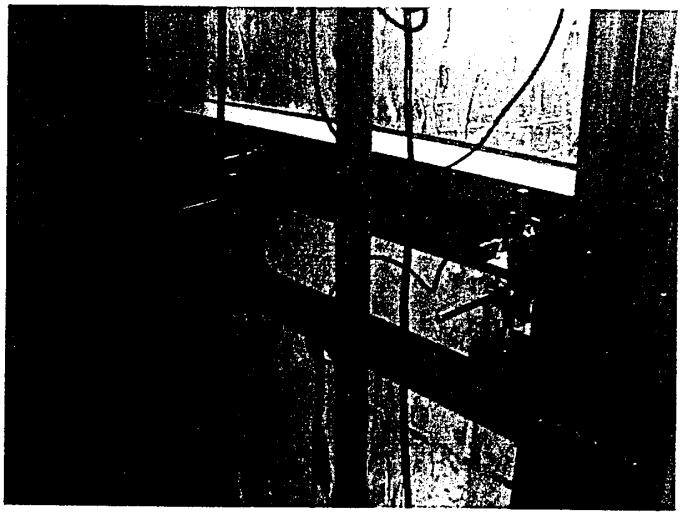


PHOTO 4. A partial view of the displacement transducers mounted on the specimen for structural test.

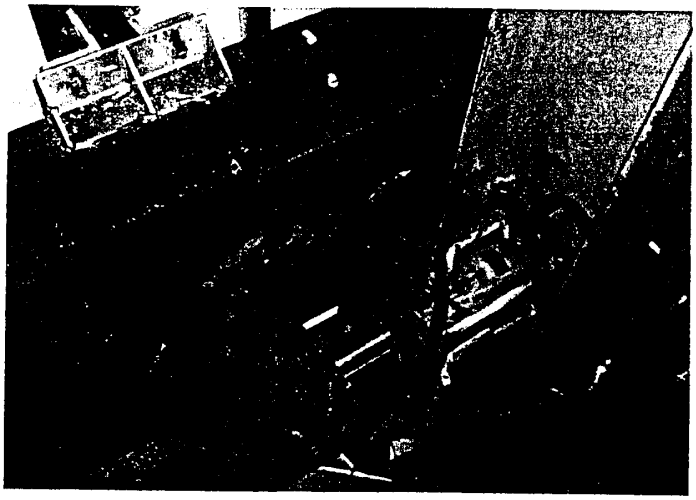


PHOTO 5. A view of the hydraulic cylinder mounted on the middle I-beam for the lateral movement test.

國立臺灣科技大學

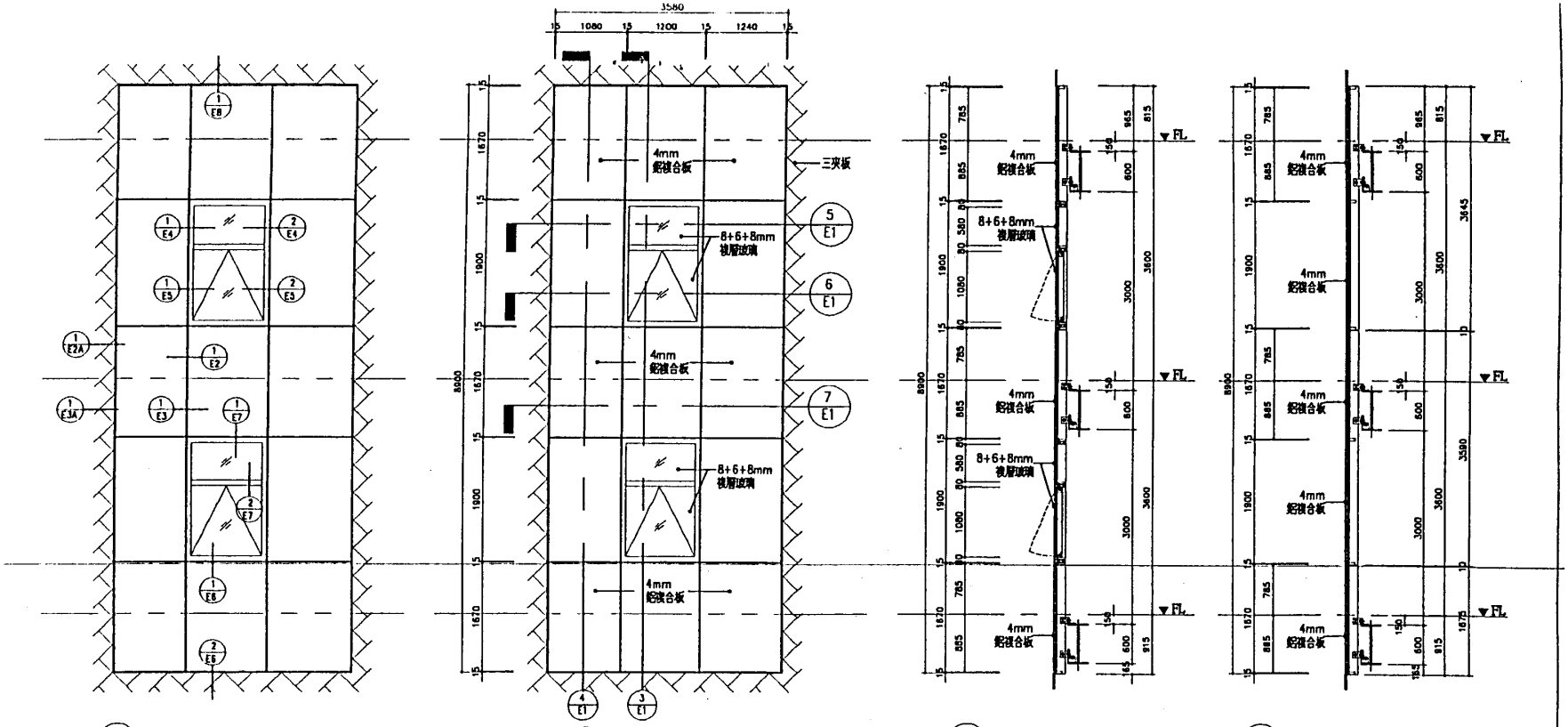
第五綜合實習工廠新建大樓

風雨測試圖面

建築師　：錢紹明建築師事務所

承包商　：德昌營造股份有限公司

協力廠商：東信輕金屬股份有限公司

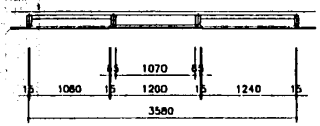


1/E1 斷面位置圖 S:1/30

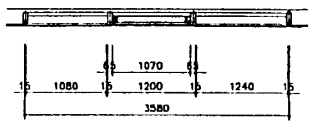
2/E1 立面圖 S:1/30

3/E1 立斷面圖 S:1/30

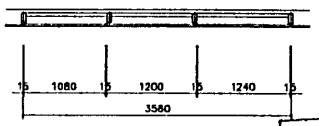
4/E1 立斷面圖 S:1/30



5/E1 平面圖 S:1/30



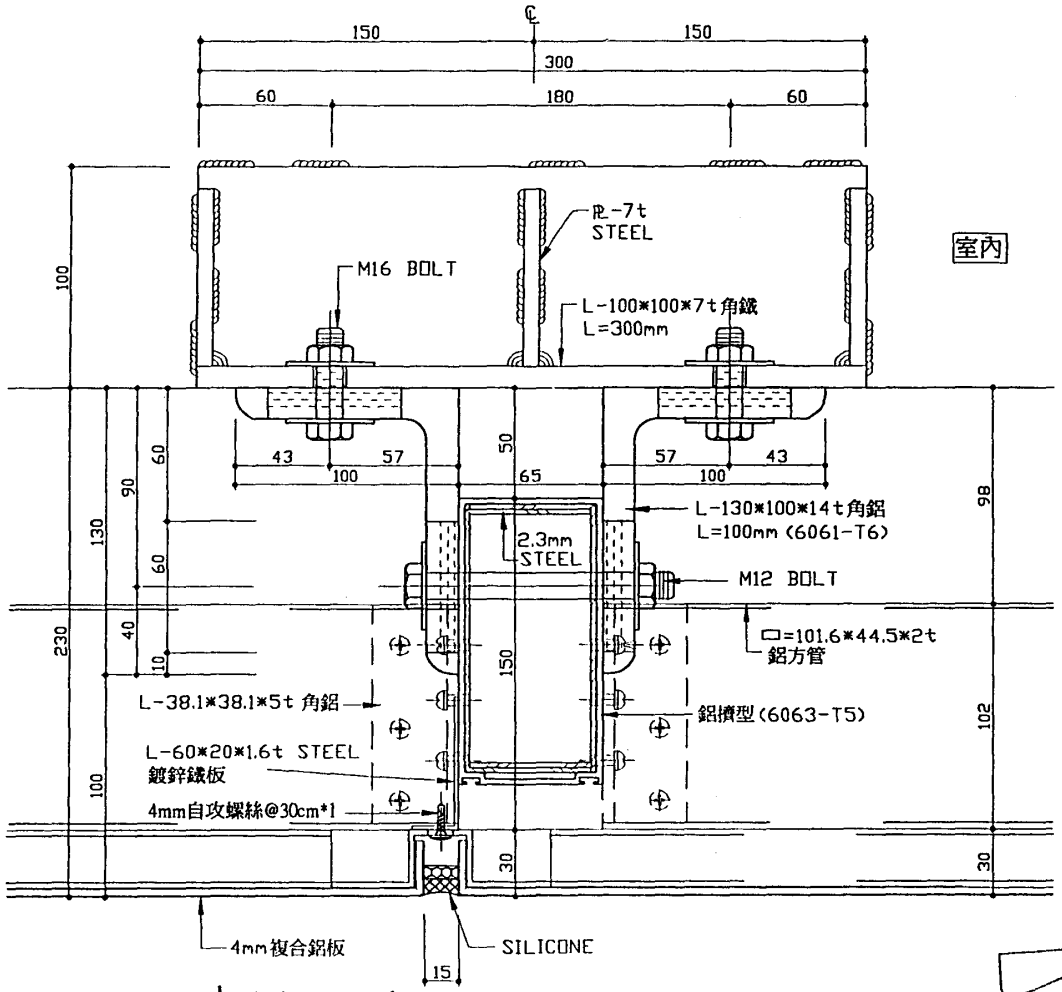
6/E1 平面圖 S:1/30

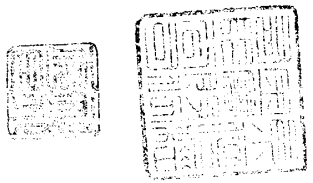


7/E1 平面圖 S:1/30

W0546/TR
WINWALL TECHNOLOGY PTE LTD

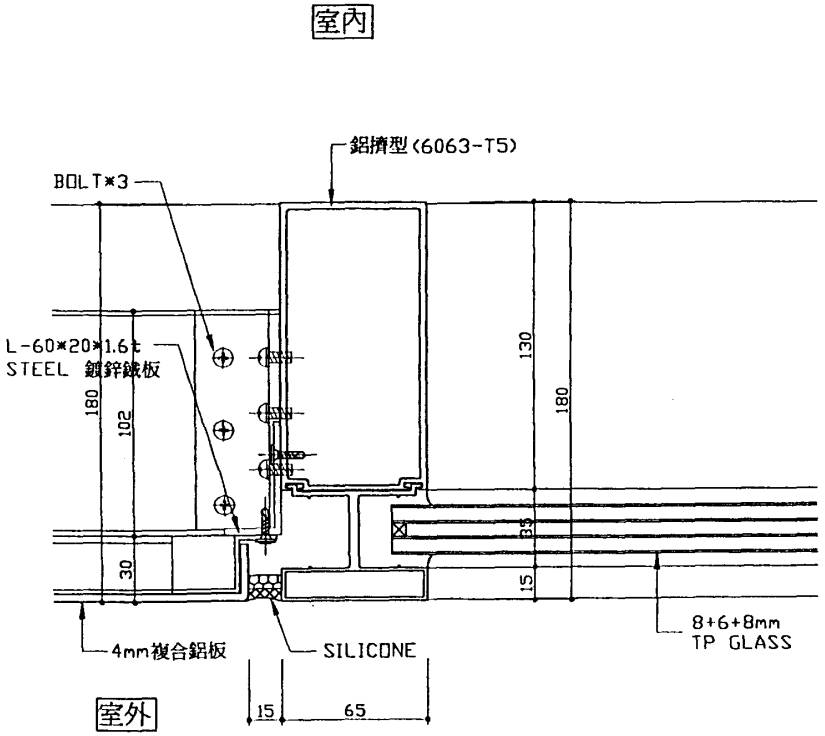
REMARK	MATERIALS RUST PROOFING FINISH QUANTITY	PLOT SCALE 1:30 DATE	東信輕金屬股份有限公司	TEL (02)25061676 FAX (02)25074791	OWNER 國立台灣科技大學 ARCHITECT 錢紹明建築師事務所 GENERAL CONTRACTOR 德昌營造	ACCEPT SIGN	PROJECT TITLE 第五綜合實習工廠 NAME OF PRODUCT 風雨試驗 NAME OF DRAWING 立面, 平面, 立斷面詳圖	JOB NO TG1 DRAWING NO E1
		DESIGNED BY	CHECKED BY	APPROVED BY				



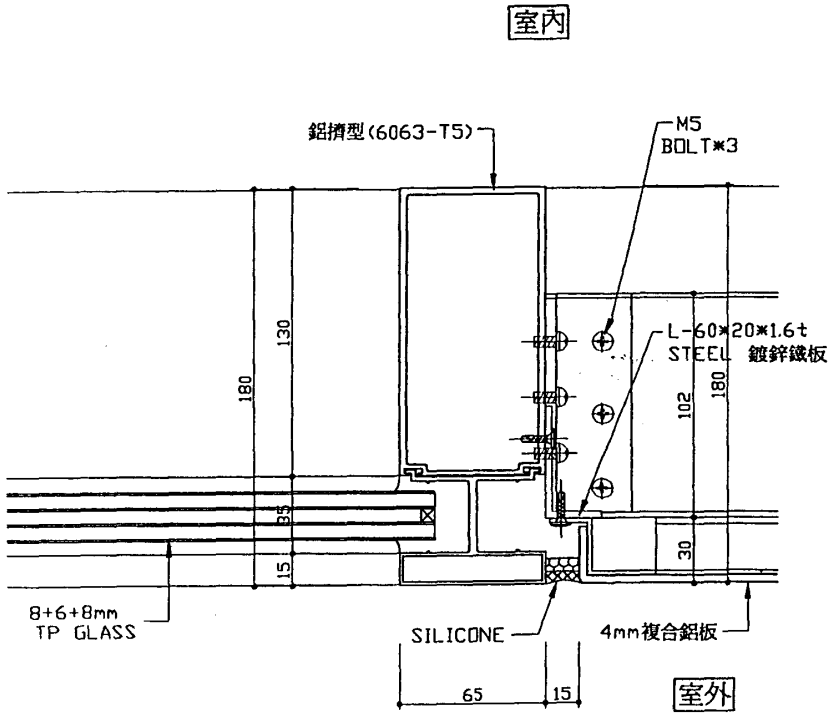


W0546/TR
WINWALL TECHNOLOGY PTE LTD

REMARK	MATERIALS	SCALE S:1/2	東信輕金屬股份有限公司	TEL (02)25061878 FAX (02)25074791	OWNER 國立台灣科技大學	ACCEPT SIGN	PROJECT TITLE 第五綜合實習工廠
	RUST PROOFING				ARCHITECT 魏紹明建築師事務所		NAME OF PRODUCT 風雨試驗
	FINISH	DRAWN BY	DESIGNED BY	CHECKED BY	APPROVED BY	CONTRACTOR 德昌營造	JOB NO TG1
	QUANTITY						DRAWING NO C-1



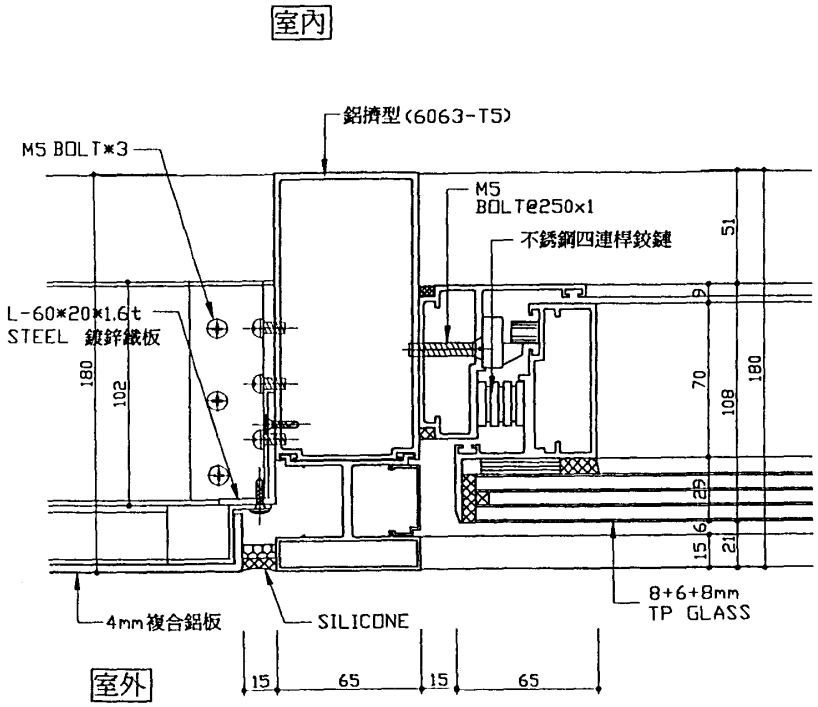
1/E-4 平斷面圖



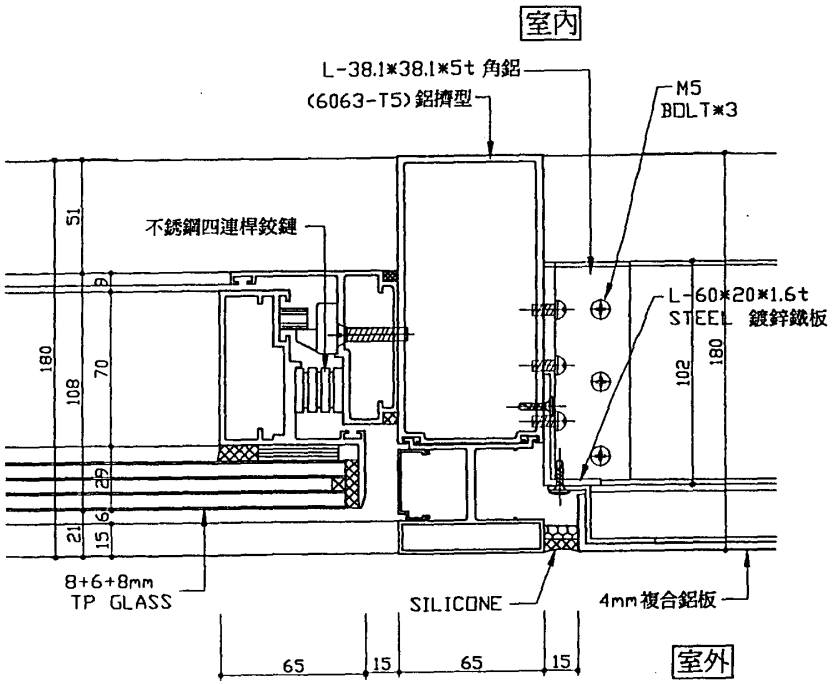
2/E-4 平斷面圖

WINWALL TECHNOLOGY PTE LTD

MARK	MATERIALS	SCALE 1:1/2	東信輕金屬股份有限公司 TEL (02)25061676 FAX (02)25074791	OWNER 國立台灣科技大學	ACCEPT SION	PROJECT TITLE 第五綜合實習工廠	JOB NO TG1
	RUST PROOFING			ARCHITECT 錢紹明建築師事務所		NAME OF PRODUCT 風雨試驗	
	FINISH	DATE	DRAWN BY / DESIGNED BY / CHECKED BY / APPROVED BY	GENERAL CONTRACTOR 鴻昌營造		NAME OF DRAWING 平斷面詳圖	DRAWING NO E4
	QUANTITY						



1/E-5 平斷面圖



2/E-5 平斷面圖

	MATERIALS	SCALE S:1/2	東信輕金屬股份有限公司 TEL (02)25041676 FAX (02)25074791	OWNER 國立台灣科技大學	ACCEPT SIGN	PROJECT TITLE 第五綜合實習工廠	JOB NO TG1
	RUST PROOFING	DATE	DRAWN BY	DESIGNED BY	CHECKED BY	APPROVED BY	ARCHITECT 錢紹明建築師事務所	NAME OF PRODUCT 風雨試驗	DRAWING NO E5
	FINISH						GENERAL CONTRACTOR 德昌營造	NAME OF DRAWING 平斷面詳圖	
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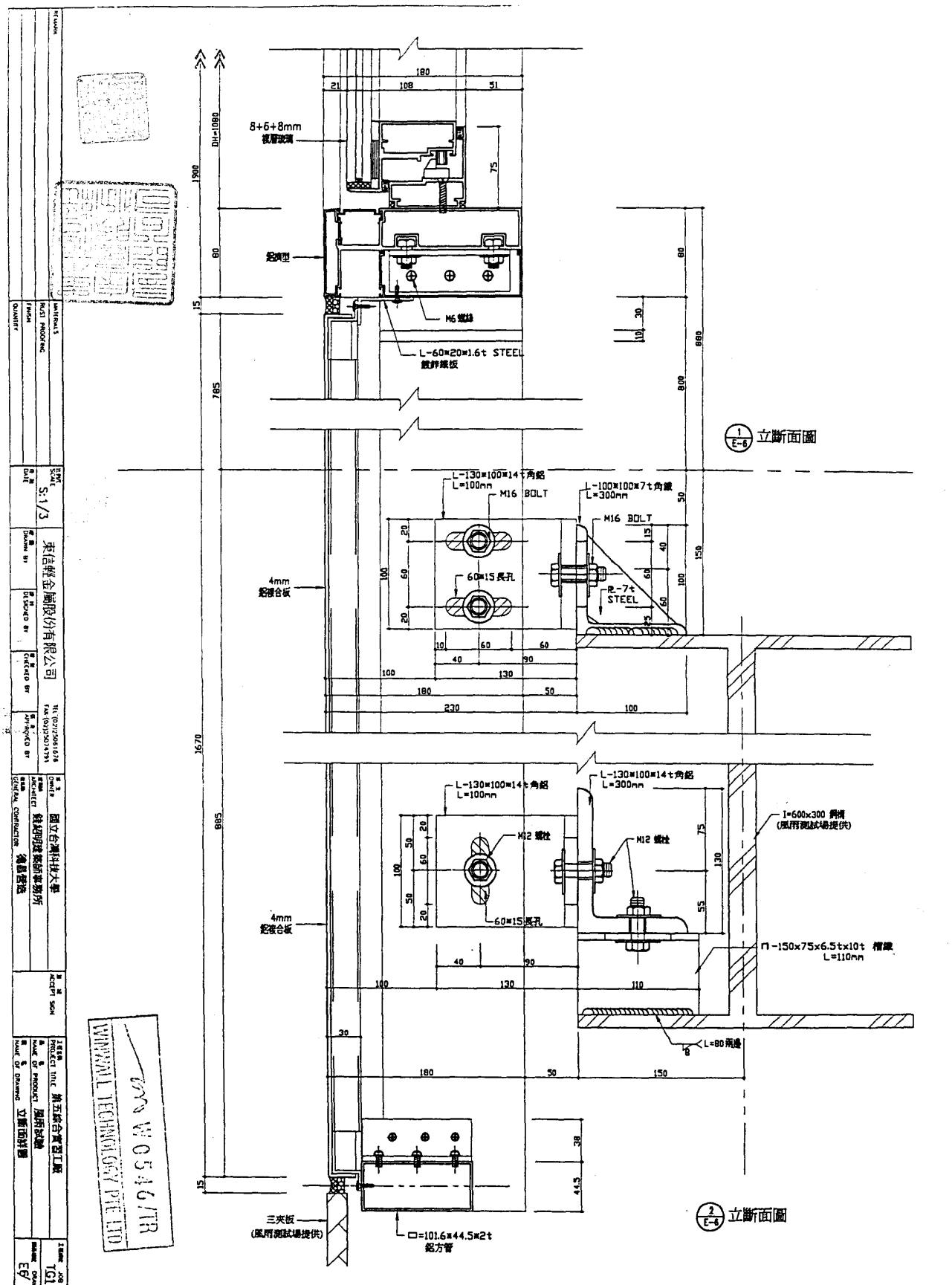
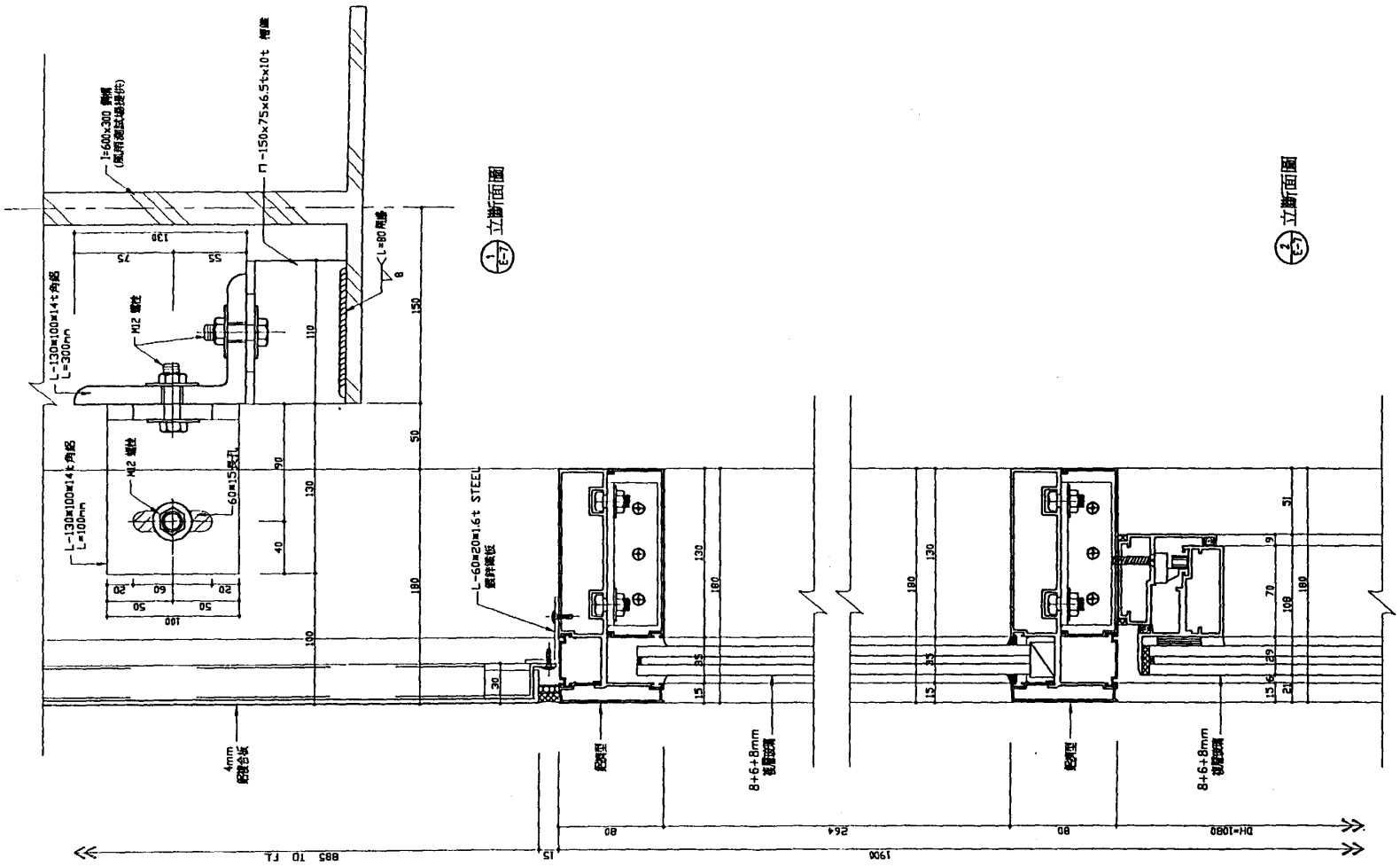


REMARK	
MATERIALS	
RUST PROOFING	
FINISH	
QUANTITY	
SCALE	S:1/3
DRAWN BY	東信鋁金屬股份有限公司
CHECKED BY	TEL:(02)2501-6139 FAX:(02)2501-6791
APPROVED BY	
OWNER	國立台灣科技大學
ARCHITECT	鍾炳建築師事務所
GENERAL CONTRACTOR	福益營造
ACCEPT SIGN	
PROJECT TITLE	第五綜合實習工廠
NAME OF PROJECT	屋頂裝飾
NAME OF DRAWING	立斷面詳圖
JOB NO	TG1
DRAWING NO	E9



REMARK

MATERIALS
RUST PROOFING
FINISH
QUANTITY

SCALE
DATE
DRAWN BY
CHECKED BY
APPROVED BY

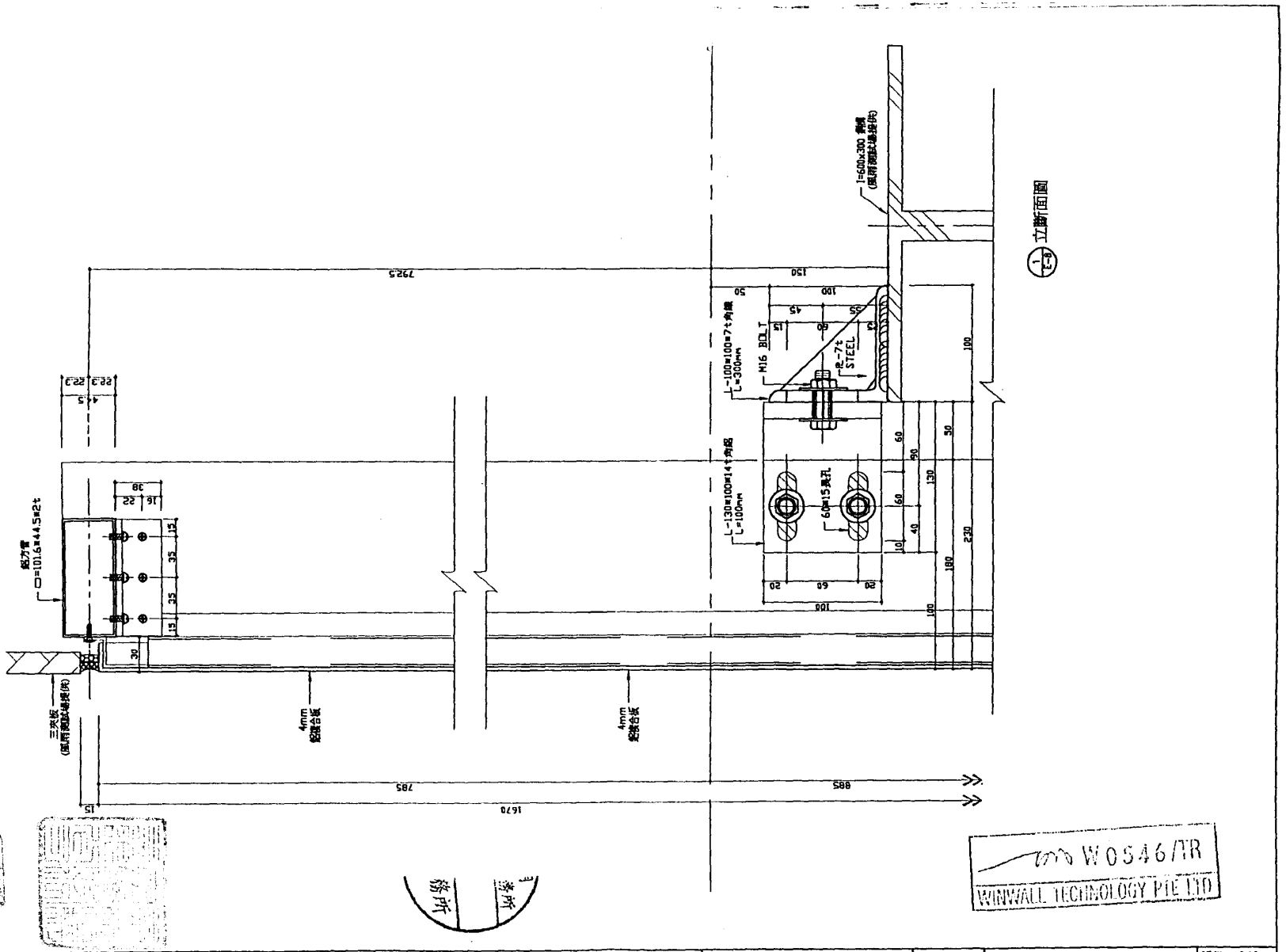
東信輕金屬股份有限公司
TEL (02)25061878
FAX (02)25074791

OWNER 國立台灣科技大學
ARCHITECT 姚紹翔建築師事務所

ACCEPT SIGN

PROJECT TITLE 第五綜合實習工廠
NAME OF PRODUCT 風雨試驗

JOB NO TG1



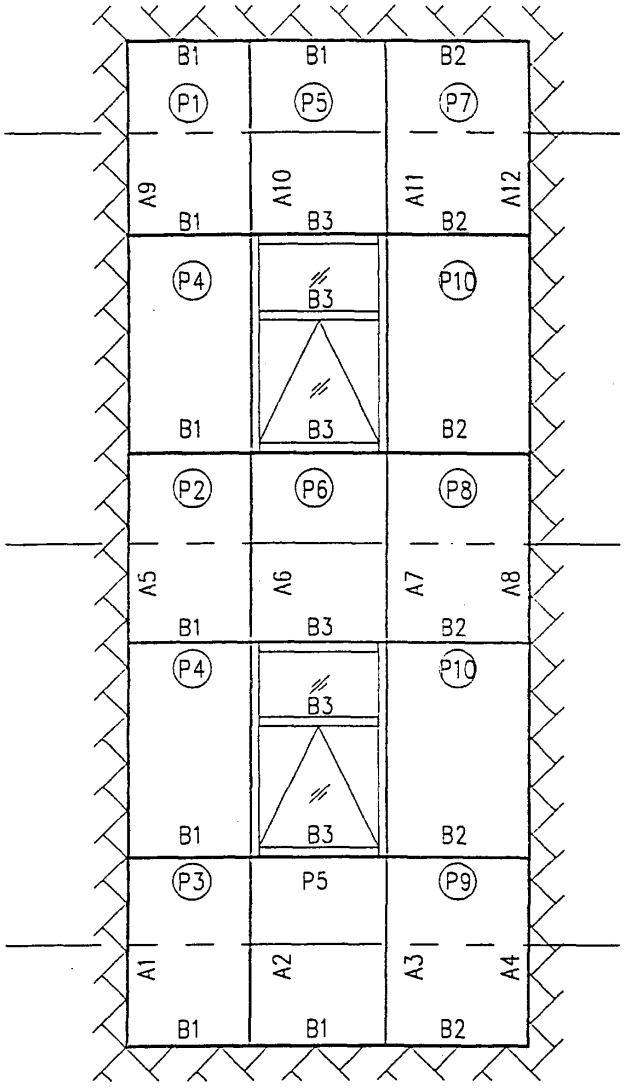
REMARK	MATERIALS	SCALE S:1/3	東信輕金屬股份有限公司 TEL (02)25081578 FAX (02)25074791	OWNER 國立台灣科技大學	ACCEPT SIGN	PROJECT TITLE 第五綜合實習工廠	JOB NO TG1
	WATER PROOFING			ARCHITECT 錢紹明建築師事務所		NAME OF PRODUCT 風雨試驗	
	FINISH	DATE	DRAWN BY	GENERAL CONTRACTOR 德昌營造		NAME OF DRAWING 立斷面詳圖	DRAWING NO E8
	QUANTITY		DESIGNED BY / CHECKED BY / APPROVED BY				

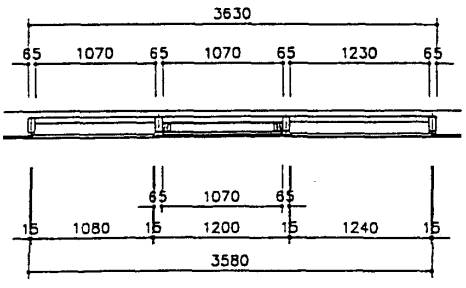
P:板片編號

A:鋁擠型編號(直料)

B:鋁擠型編號(橫料)

材料編號位置圖





平面圖