Overseas Curtain Wall: Worth the Trip?

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Overseas Curtain Wall: Worth the Trip?

- Three projects
  - Jameson House
  - Nassau Airport Expansion
  - Hotel Georgia
- Two Curtain Wall Manufacturers
  - Yuanda Aluminum Industry Engineering Co.
  - Mei Te Curtain Wall System Co.
- Plant Set-Up
- Fabrication Process
- Quality Control
- Mock-Up Testing

Changing the Local Skyline? (and not so local)

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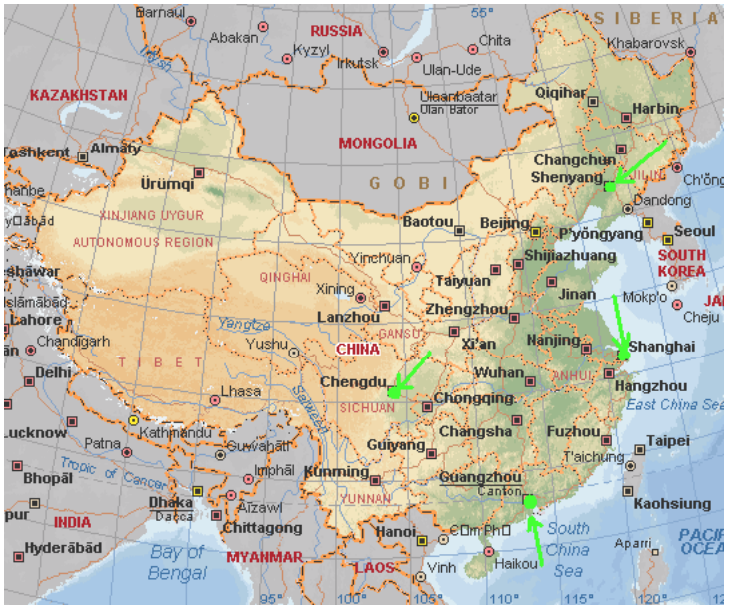
Yuanda's Background

- Shenyang Yuanda Aluminum Industry Engineering Co., Ltd.
- Established in Shenyang, China, in 1993
- In 2007, built an industrial park covering 1 km²
- Largest provider of CW in the world? --- with 3 other plants in Shanghai, Chengdu and Foshan, total yearly production capacity of 12,000,000 m²
- Strong presence internationally --- branches in 17 countries around the world
- Other sectors include elevators, escalators and wind power



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Some Yuanda Projects
Water Cube & National Stadium, Beijing

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Some Yuanda Projects
Cocoon, Tokyo

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Some Yuanda Projects
Northern Lights, Kazakhstan

Some Yuanda Projects
Trident Pentominium Tower, Dubai

Yuanda's Showroom

Yuanda's Showroom

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Yuanda's Showroom

Yuanda's Shenyang Plant

- Many buildings (20 +) make up Shenyang manufacturing base
  - About 80% for CW
  - 20% for other

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Yuanda's Shenyang Plant

- Engineering and management housed in separate modern facilities
- Split by geographical sectors (e.g. domestic, Europe, Middle East, North America, etc.)

Yuanda's Shenyang Plant

- Manufacturing buildings split by areas sharing similar standards (e.g. Japan & North America) → easier for fabrication & design to meet criteria

Inside of Yuanda's Plant

- Large, spacious & clean shop
- Organized by project
- Not assembly line
- No overhead equipment

Yuanda's Fabrication Process

- First time design team deals with manufacturer & design engineers → easier to sort out questions / concerns / recommendations in person
- Language barrier is present → alleviated with help of translators & willingness to communicate by all parties
- Units fabricated by drawing → no site measuring

Yuanda's Fabrication Process

- Sign at each assembly area

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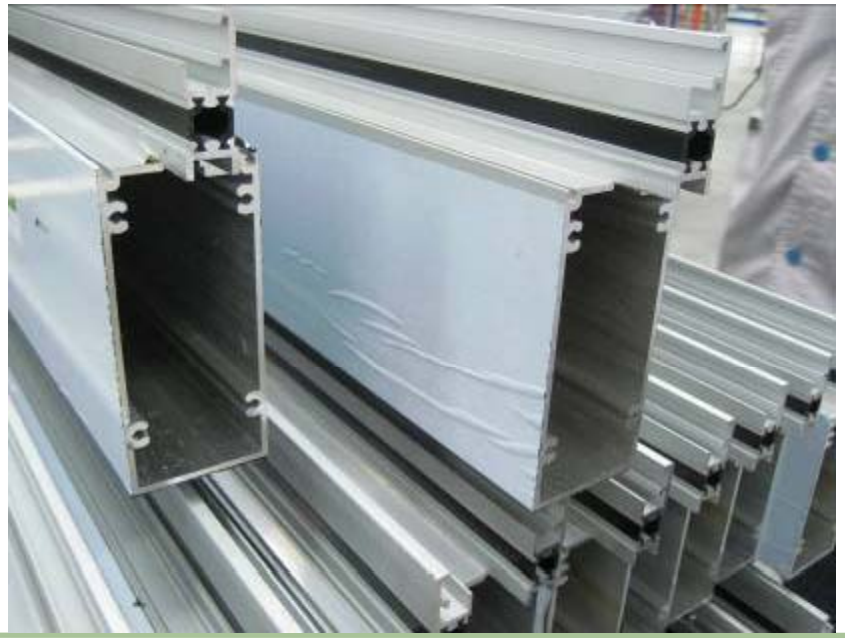
Yuanda's Fabrication Process

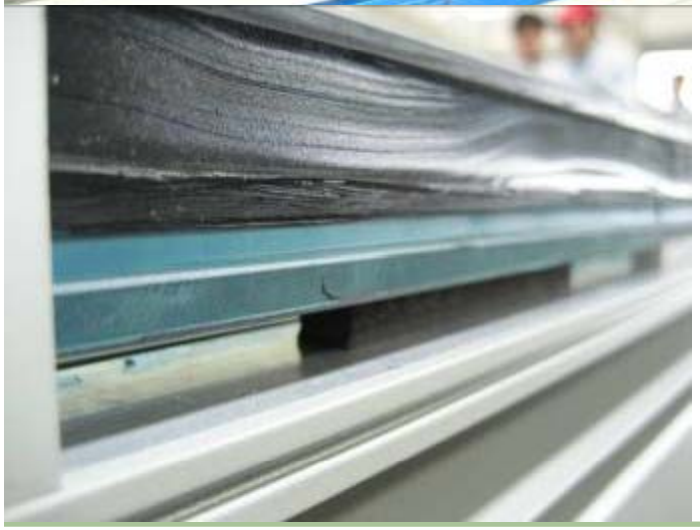
- Arrival of extrusions
- Cutting and milling station
  - Separate CNC machines for each task (Germany, Italy, Austria, Netherlands) e.g.→ length → corner joinery → weep holes
  - Shop drawing for each step



Yuanda's Fabrication Process

- Assembly station
  - Moved by cart
  - Materials brought to each frame
  - More reliance on manual labour, e.g. caulking guns, manual diagonal dimensions vs. jig, IGUs set by hand vs. hoist
  - Labour intensive processes, e.g. masking joints, dots of caulking

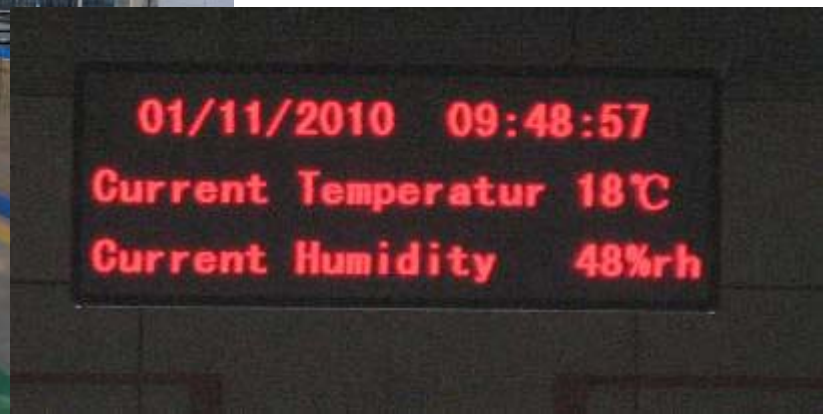
Yuanda's Fabrication Process



- Glass from China
  - Jameson House → Guangdong Golden Glass
  - Nassau Airport → Shanghai Yaohua Pilkington Glass
- Low-e specified is found in North America
- Similar for interlayers

Yuanda's Fabrication Process

- Brand labeled sealants being used
- Sealant Curing Room



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Yuanda's Fabrication Process

- Shipping via container by truck & barge
- Shop drawing of each container and position of each crate
- For Nassau, delivery takes 4 weeks
- Issues with order of arrival

Yuanda's Quality Control

- Extrusion check
  - 10% for dimension, colour, coating, finish, adhesion, uniformity, scratches
- Sealant tests
  - Butterfly & Pull tests at start-up and refill
  - Results documented, photographed, filed for 3 yrs
  - 3 to 5% for SSG adhesion test / deglazing
- IGU check
  - 100% for size tolerance, continuity of perimeter seal, size & location of scratches, presence & location of low-e

Yuanda's Quality Control

- Plant is ISO certified
- Documentation is paper based
- Labels for extrusions, units and glass
- Units individually labeled, cross referenced to site installation drawings
- Checklist for QC follows frame
- Each step checked 3 times: self-, cross-, and inspector's
- Most documents in Chinese (some English) – possibility of translation errors

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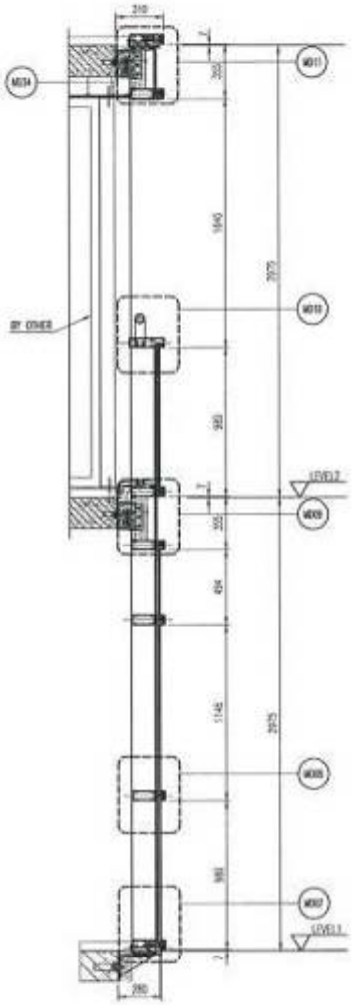
Mock-Up Testing at Yuanda

- Shenyang Kezheng Construction Engineering Testing Co., Ltd. (SKCET)
- Independent lab
- Indoor facility, allowing multiple mock-ups at same time, 5 stories high
- Good knowledge of common ASTM / AAMA
- Not so much for Miami-Dade → 3rd party agency
- Unheated facility – affected some tests

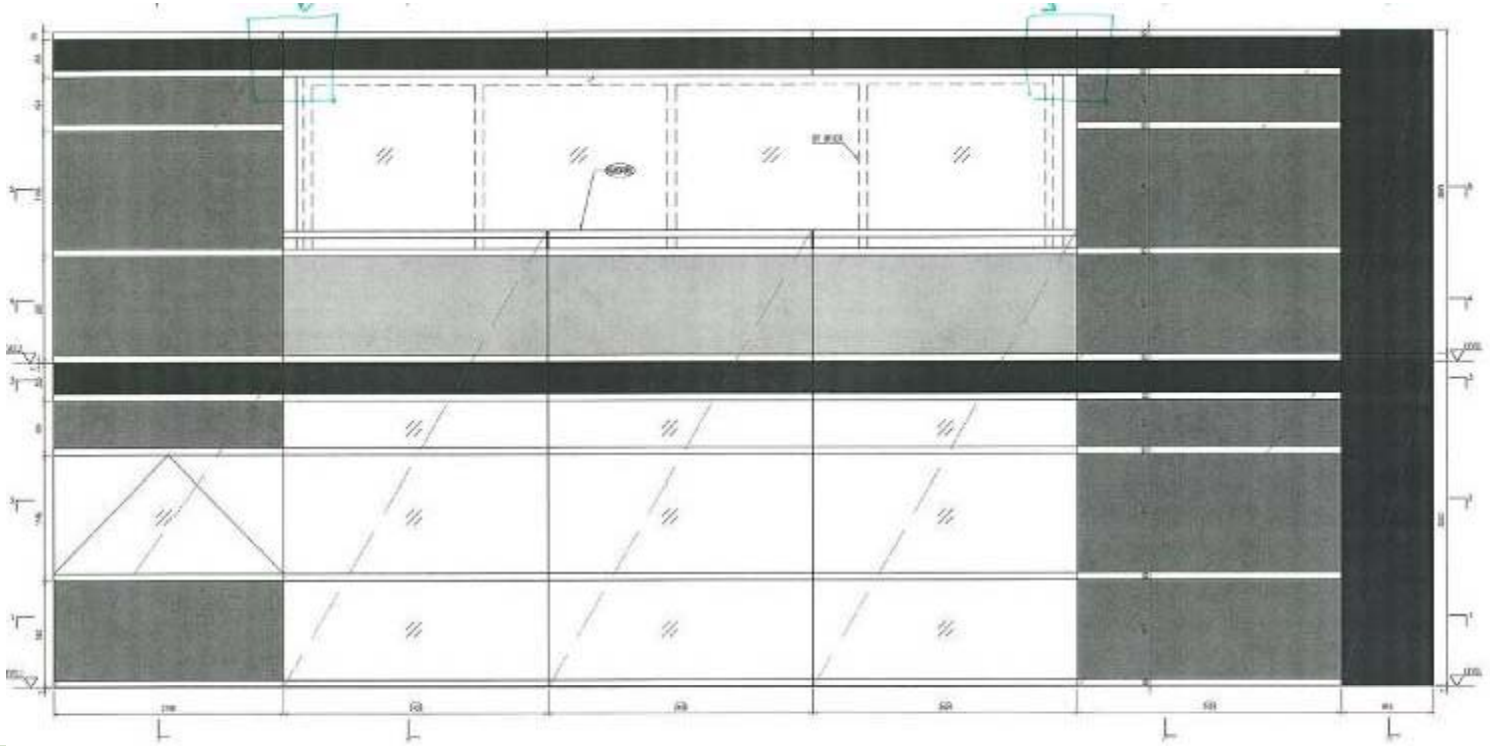
Mock-Up Testing at Yuanda

- System control and measurements centralized in control rooms
  - Pressurization fans
  - Electronic meters for pressure, flow and linear transducers
- Data saved in spreadsheet format
- SKCET issues their own lab report

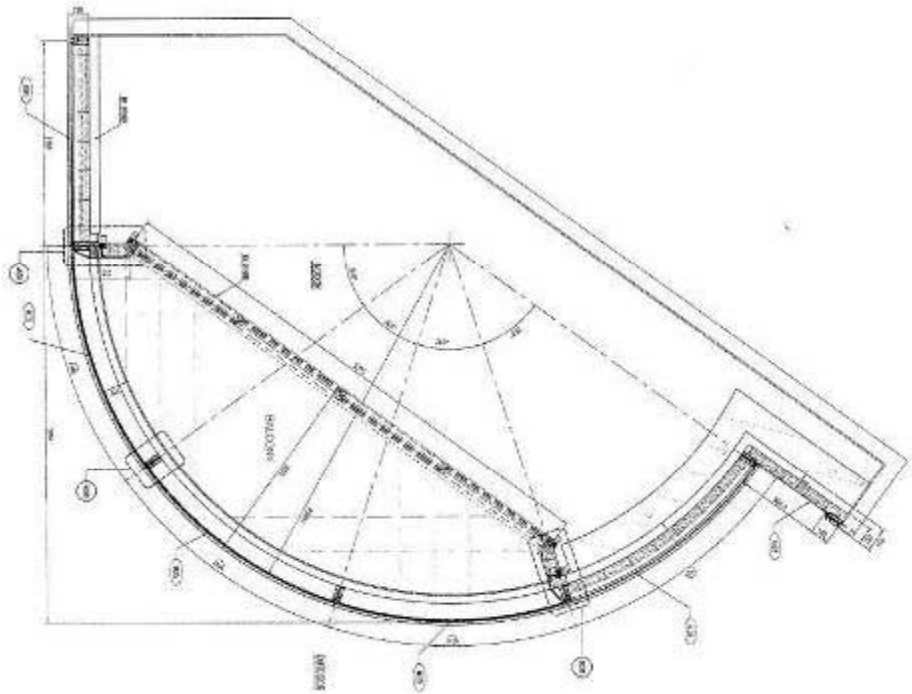
Mock-Up Testing at Yuanda



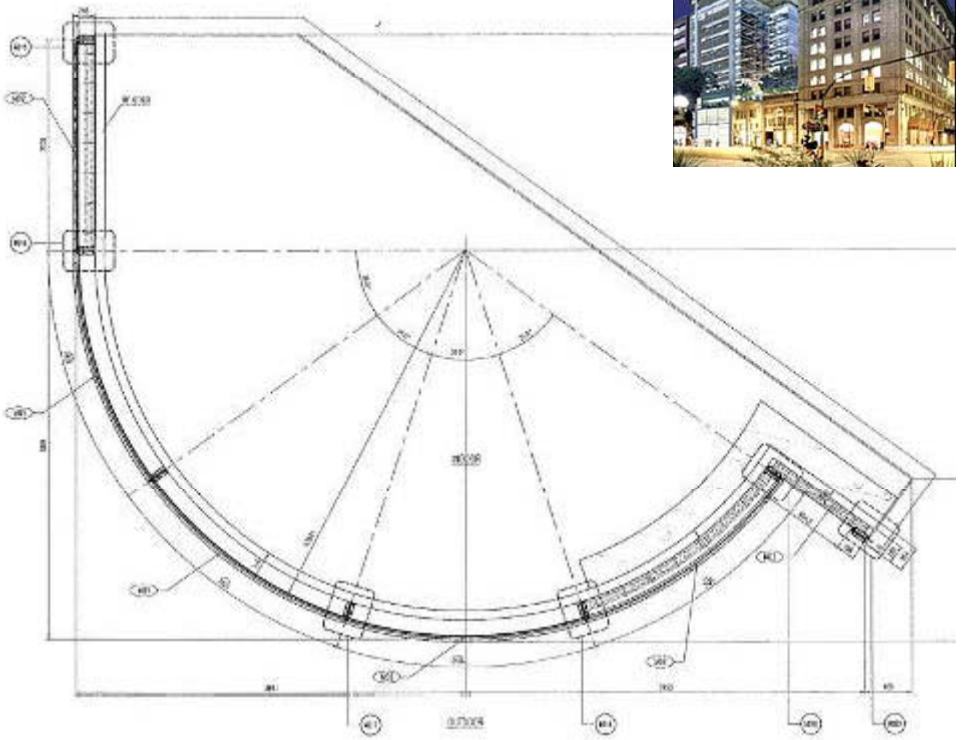
- Mock-up for Jameson House consisted of:
  - Two stories high
  - Straight and curved sections
  - Deck interface



Mock-Up Testing at Yuanda



Deck above



Full glazing below

Mock-Up Testing at Yuanda

- Intent was to test 3D deck slab – curtain wall interface
- Issues with mock-up:
  - Missing waterproofing at deck
  - Deck construction was sheet metal welded to top of steel frame
  - Sheet metal inserted after mock-up constructed
- Results:
  - Water leakage at interface of CW outside the slab, of deck junction and inner deck wall
  - Site condition not tested
- Recommendation:
  - Field mock-up to confirm performance of WP transition

Mock-Up Testing at Yuanda

- Testing to ASTM and AAMA standards per projects specs and VBBL
- Results: CW met criteria
- Of note:
  - Water leakage at deck interface and at chamber connection throughout
  - After repeat E330 at 1.5 x design wind pressure, three vertical split mullions had joint widen to 5 mm between floors though transducers said 1 mm

Test sequence shall be as follows:

1. Air Leakage (ASTM E283) infiltration then exfiltration
   Acceptance criteria: < 0.178 L/s/m2 @ 300 Pa
2. Static Water Resistance (ASTM E331)
   Acceptance criteria: No water leakage for 15 minutes @ 700 Pa
3. Dynamic Water Resistance (AAMA 501.1)
   Acceptance criteria: No water leakage for 15 minutes @ equivalent of 700 Pa
4. Structural Performance @ Design Wind Pressure of ____ Pa (ASTM E330) inward and outward for minimum of 10 sec
   Acceptance criteria: Deflection < L/175, No permanent set
5. Repeat Static Water Resistance (ASTM E331)
   Acceptance criteria: No water leakage for 15 minutes @ 700 Pa
6. Seismic Movement at Elastic Design Displacement of +/- ___ mm (AAMA 501.4)
   Acceptance criteria: After three cycles +/- ___ mm, no glass breakage, any damage repairable on site without part replacement, no wall component may fall off, post displacement performance (water leakage and structural) can be obtained with adjustments that do not require wall disassembly.
7. Repeat Static Water Resistance (ASTM E331)
   Acceptance criteria: No water leakage for 15 minutes @ 700 Pa
8. Repeat Structural Performance @ 1.5 x Design Wind Pressure (ASTM E330)
   Acceptance criteria: No catastrophic failure and no component to fall off.
9. Seismic Movement at Inelastic Design Displacement of +/- ___ mm or 1.5 x Design Displacement, whichever is greater (AAMA 501.4)
   Acceptance criteria: After three cycles +/- ___ mm, glass may crack, seals may fail, but no catastrophic failure, and no component to fall off

Mock-Up Testing at Yuanda

- Mock-up for Nassau Airport consisted of:
  - Three 8-ft wide panels, with max height of 20 ft
  - No stack joint or operables
  - Selected because tallest span for project

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Mock-Up Testing at Yuanda

- Test sequence to meet project specs and Miami-Dad County requirements

The test sequence is as follows:

1. Uniform static load test – Pre-load at +52.5 psf (ASTM E330) for 10 seconds
2. Air Infiltration Test (ASTM E283)
   a. 1.57 psf
   b. 6.24 psf (Qa < 0.06 cfm/ft²)
3. Water leakage test (ASTM E331)
   a. +15.00 psf for 15 minutes
4. Dynamic Water Penetration Test (AAMA 501.1)
   a. +15.00 psf for 15 minutes
5. Thermal Cycling Test (AAMA 501.5 – 3 cycles)
6. Air Infiltration Test (ASTM E283)
   a. 1.57 psf
   b. 6.24 psf (Qa < 0.06 cfm/ft²)
7. Water Infiltration Test (ASTM E331)
   a. +15.00 psf for 15 minutes
8. Uniform static load Test (ASTM E330)
   a. Positive Loads
      i. +52.50 psf for 30 seconds (Positive Pre-Load Load)
         1. Deflection < L/180 (for span < 156" ----horizontals)
         2. Deflection < L/240 + 0.25" (for spans > 162" -------verticals)
         3. Permanent Set < 0.2%L
         4. Recovery > 90%
      ii. +70.00 psf for 30 seconds (Positive Design Load)
         1. Deflection < L/180 (for span < 156" ----horizontals)
         2. Deflection < L/240 + 0.25" (for spans > 162" -------verticals)
         3. Permanent Set < 0.2%L
         4. Recovery > 90%
9. Uniform static load test – Set load at -33.75 psf
10. Uniform static load Test (ASTM E330)
    a. Negative Loads
       i. -45.0 psf for 30 seconds (Negative Pre-Load Load)
          1. Deflection < L/180 (for span < 156" ----horizontals)
          2. Deflection < L/240 + 0.25" (for spans > 162" -------verticals)
          3. Permanent Set < 0.2%L
          4. Recovery > 90%
       ii. -60.00 psf for 30 seconds (Negative Design Load)
          1. Deflection < L/180 (for span < 156" ----horizontals)
          2. Deflection < L/240 + 0.25" (for spans > 162" -------verticals)
          3. Permanent Set < 0.2%L
          4. Recovery > 90%
11. Water Infiltration Test (ASTM E331)
    a. +15.00 psf for 15 minutes
12. ~~Uniform static load test – Set load at +52.50 psf~~
13. Uniform static Load Test (ASTM E330)
    a. Positive Loads
       i. +105.00 psf for 30 seconds (Positive Test Load)
          1. Permanent Set < 0.2%L
          2. Recovery > 80%
14. Uniform static load test – Set load at -33.75 psf
15. Uniform static Load Test (ASTM E330)
    a. Negative Loads
       i. -90.00 psf for 30 seconds (Negative Test Load)
          1. Permanent Set < 0.2%L
          2. Recovery > 80%
16. Small Missile Impact (TAS 201 and ASTM E1886/E1996)
17. Large Missile Impact (TAS 201 and ASTM E1886/E1996)
18. Cyclic Load Test (TAS 203 and ASTM E1886/E1996)
    a. Positive Loading at +70.00 psf
       i. Permanent Set < 0.2%L
       ii. Recovery > 90%
    b. Negative Loading at -60.00 psf
       i. Permanent Set < 0.2%L
       ii. Recovery > 90%

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Mock-Up Testing at Yuanda

- SKCET familiar with more standard ASTM / AAMA tests, not so much with Miami-Dade requirements
- Thermal testing and associated air & water tests not done: → 10-day lead time → temperature
- Calibration of fans, transducers, spray racks, etc., all checked before testing
- Water test had leaks at chamber itself and chamber connection throughout test, but not affecting CW

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Mock-Up Testing at Yuanda

- Uniform Static Load Test ASTM E330 was ok until positive proof load (105 psf or 5030 Pa)
  - Structural attachment of sill track to chamber failed
  - Caused CW to buckle in and decouple vertical mullion
  - Investigation: undersized fasteners
- New fasteners and sill track
- Qualify fix with ASTM E331 and Restart ASTM E330

Mock-Up Testing at Yuanda

- ASTM E 1886 / E 1996: Performance of Exterior Windows, Curtain Wall, Doors and Impact Protective Systems Impacted by Missile(s) and Exposed to Cyclic Pressure Differential
- Consists of three parts:
  - Small Missile Impact Test
  - Large Missile Impact Test
  - Cyclic Load Test

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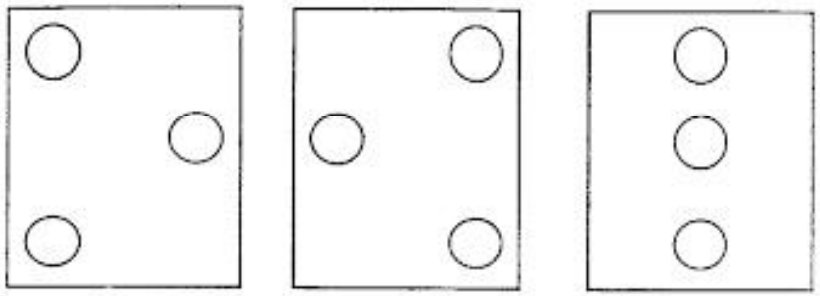
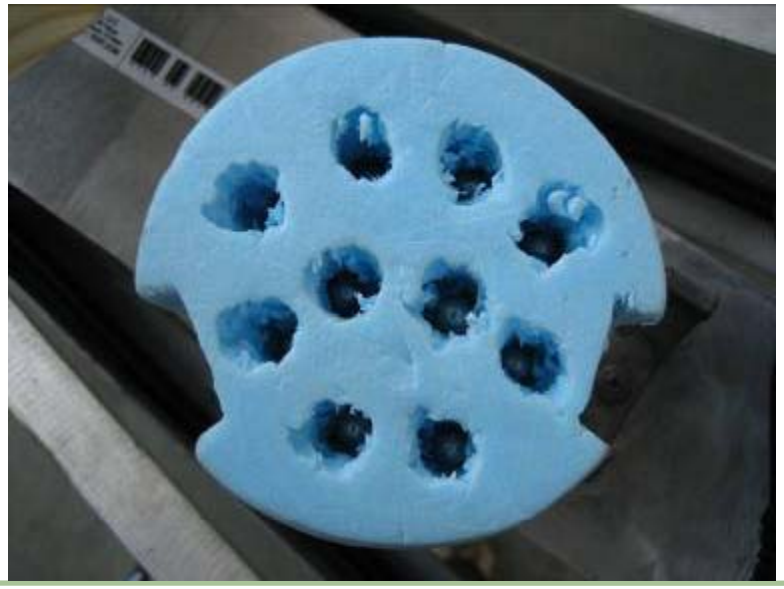
Mock-Up Testing at Yuanda



- Small Missile Impact Test: to test the IGUs with 0.06” thick interlayer (1.28 PVB), for units located at 30 ft and higher above grade



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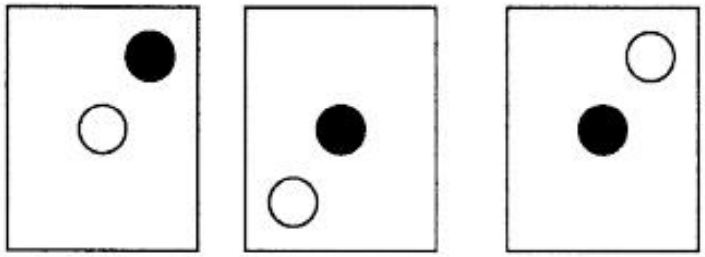
Mock-Up Testing at Yuanda

- Large Missile Impact Test: to test the IGUs with 0.09” thick interlayer (2.28 SGP), for units located up to 30 ft above grade



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Mock-Up Testing at Yuanda

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Mock-Up Testing at Yuanda

- Cyclic Load Test: to verify that the IGUs withstand cyclical induced positive and negative pressures
- Pass / Fail Criteria: “the test specimen shall resist the large or small missile impacts, or both, with no tear formed longer than 130 mm (5 in.) and wider than 1 mm (1/16 in.) through which air can pass, or with no opening formed through which a 76 mm (3 in.) diameter solid sphere can freely pass when evaluated upon completion of missile impacts and test loading program” (ASTM E 1996 – 09)
- Results: Mock-up met criteria

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Mei Te's Background

- Shanghai Mei Te Curtain Wall System Co., Ltd.
- Manufacturing partner for Envision
- Established in 1993 by Amtronic (Singapore) and Shanghai Building Material Group (China)
- Smaller in size than Yuanda, but large by Canadian standards --- newly constructed facility covers 100,000 m² in Shanghai headquarters
- Focus is more in Asia, but expanding with projects and partners overseas

Some Mei Te Projects
Changfeng Shopping Centre, Shanghai

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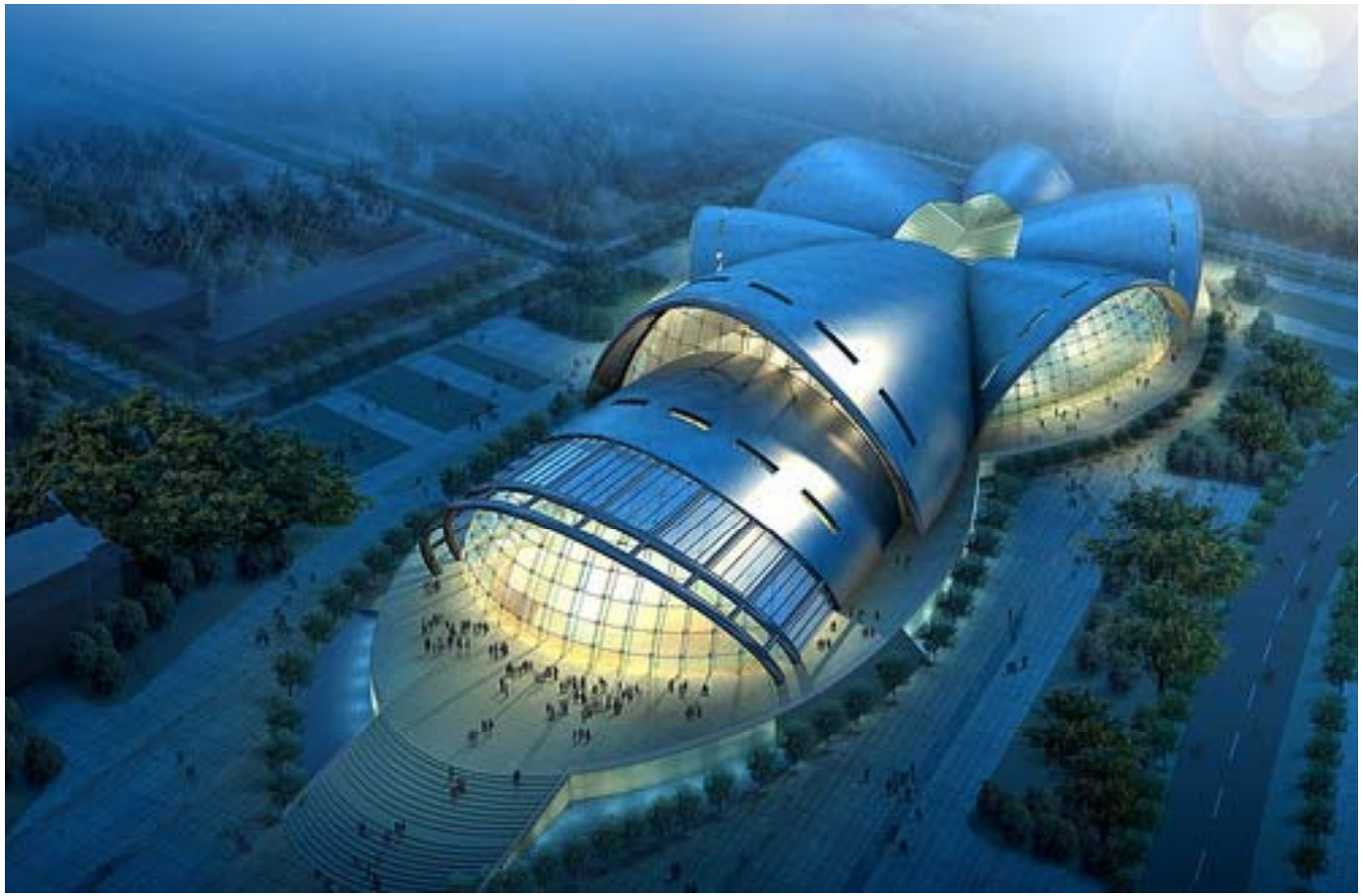
Some Mei Te Projects
National Academy for Performing Arts, Trinidad



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Some Mei Te Projects
Bengal International Conference Centre, Bengal

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Some Mei Te Projects
Chicago Burnham Pointe, USA

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Mei Te's Shanghai Plant

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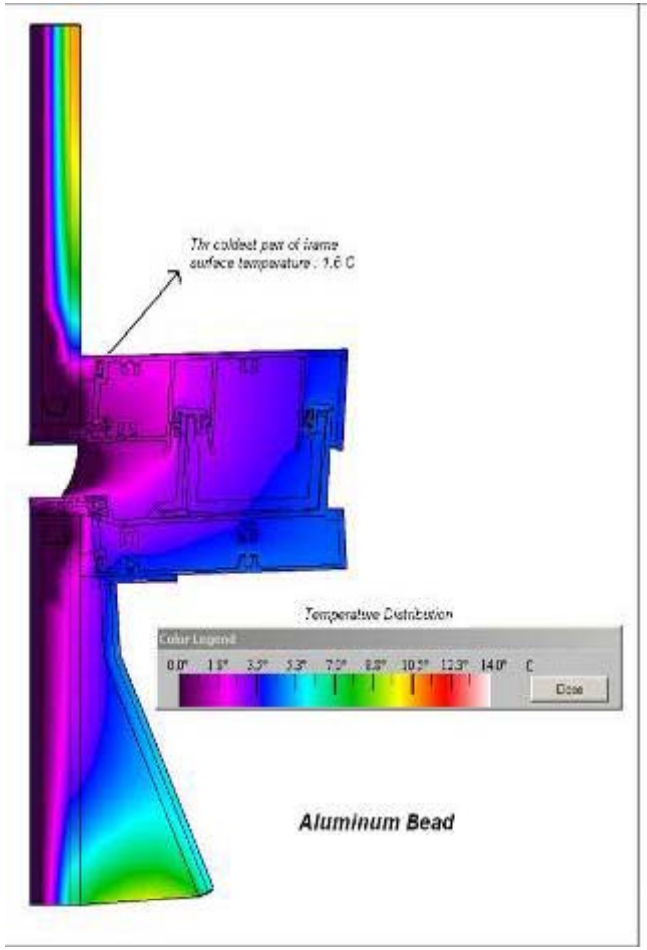
Inside of Mei Te's Plant

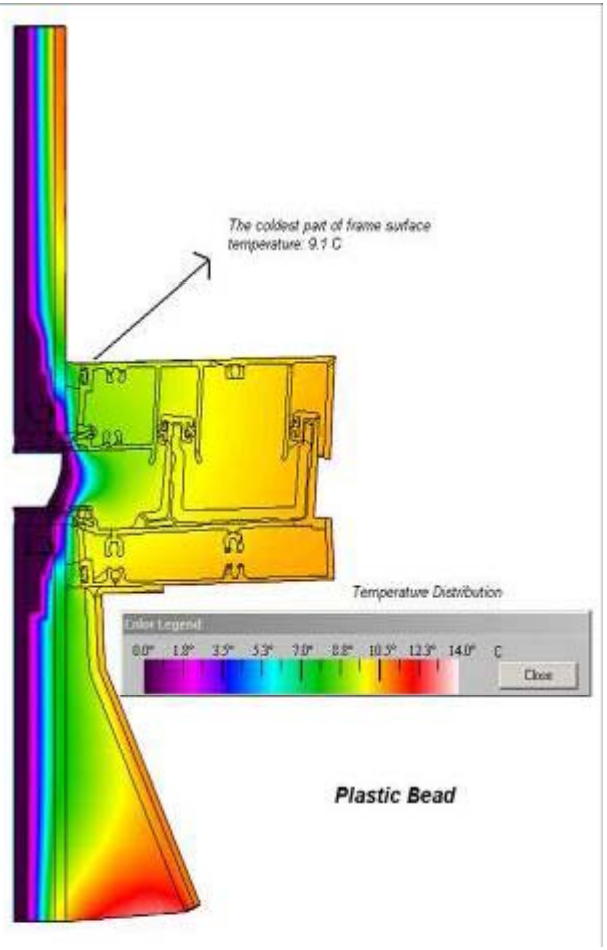
Inside of Mei Te's Plant

- One shop for all projects
- Divided by work station rather than assembly line
- All projects go through same stations
- Different standards for different projects in same space – potentially causes some issues with fabrication requirements
- More used to building CW for warm climate – design considerations needed to be discussed

Cold Climate Considerations

- Discussions with Mei Te to address thermal performance concerns
  - Extent of insulation in backpans
  - Tightness of insulation in backpans during fabrication
  - Key components improved by changing material





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Mei Te's Fabrication Process

- Arrival of extrusions
  - Mei Te removes protective covering to inspect extrusions and then recovers them
  - Due to issues with inacceptable extrusions and finishes in the past
- Cutting and milling station
  - Modern CNC machines, from Europe

Mei Te's Fabrication Process

- Assembly station
  - Frames fabricated at work station
  - Moved by cart to next station for insulation and backpan
  - Also more reliance on manual labour, e.g. caulking guns, manual diagonal dimensions vs. jig, etc.

Mei Te's Fabrication Process

- Sealant:
  - Brand labeled sealants being used (QC)
  - Sealant applied in a climate controlled chamber, but curing is in uncontrolled plant
- Packaging:
  - Schedule too tight – IGUs will be done in Vancouver
  - Shrink wrap is installed over backpan insulation where spandrel glass is missing.
  - Units crated horizontally, separated by an air gap
  - Miscellaneous parts temporarily attached for shipping wherever possible

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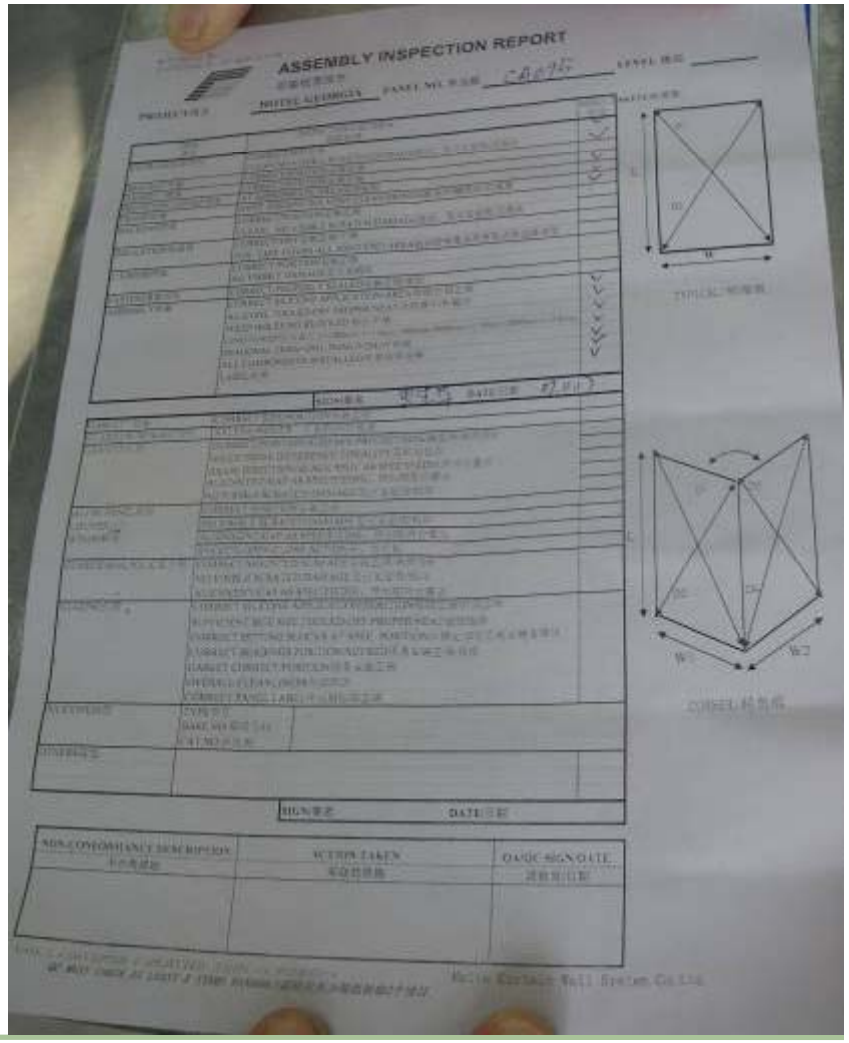
Mei Te's Quality Control

- Concerns with some disorganization with QC procedures after first visit
  - MH present for 2 weeks
  - Discussed issues relating to fit of insulation, sealing of anchors at backpans and horizontal to vertical butt joints at backpans
- Documentation is paper based
- Units individually labeled
- Extrusion Inspection Checklist
- Each frame is inspected by foreman at fabrication station
- Random checks by QC inspectors as 2nd check
- Assembly Inspection Report
- Most documents in Chinese (some English) – possibility of translation errors
- Plant is ISO certified



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Mei Te's Quality Control

- **Extrusion check**
  - Every extrusion visually checked
  - 2% for coating thickness measurement
  - 5% for coating adhesion tests
  - Extrusion inspection report includes: surface hardness, visual defects, extrusion thickness, straightness and twist
- **Sealant tests**
  - Butterfly, Pull & Adhesion peel tests at start-up and refill
  - No deglazing was being done
- **Glass check**
  - 100% for chips, spalls and continuity of perimeter seal
  - 2 to 3% for size, roller wave, distortion, etc.
  - Results written on inspection form



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Mock-Up Testing at Mei Te

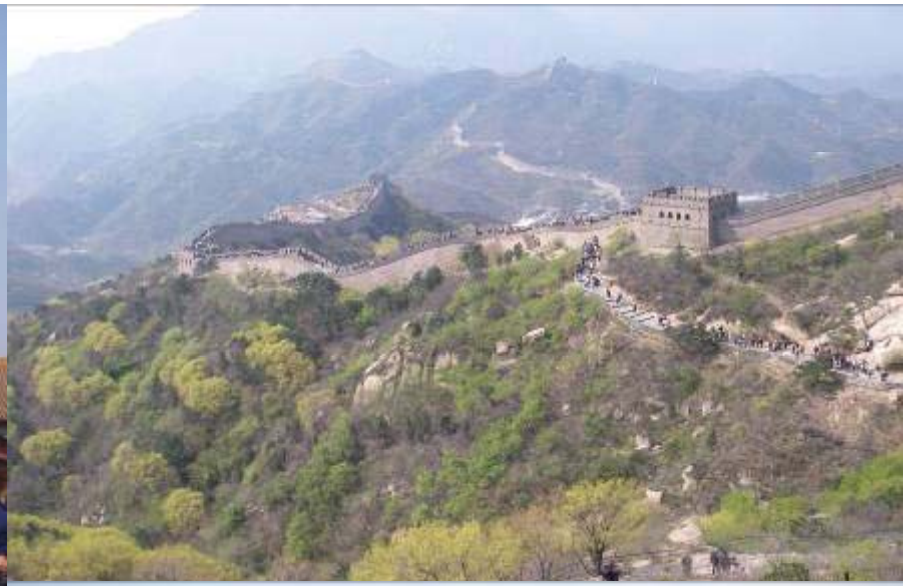
- Shanghai Research Institute of Building Science (SRIBS)
- Independent lab
- Familiar with ASTM and AAMA standard tests specified for project
- Mock-up consisted of 2-1/2 storey high unitized CW with one awning operable and two outside corners
- Test sequence ran smoothly, CW met criteria set by project specs and VBBL

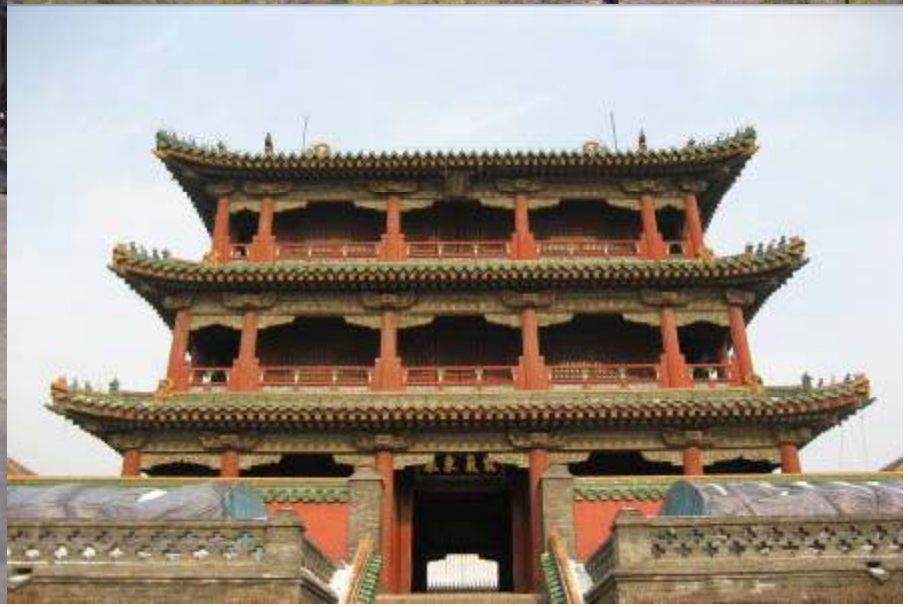
INDEX目录

Worth the Trip?

- Meeting with manufacturer in person
- Verifying fabrication meets design intent, codes & standards and shop drawings
- Ensuring specified products are used
- Reviewing quality control procedure
- Verifying that testing is carried out as intended
- Understanding logistics in shipment and impact on site, e.g. schedule, sequence, breakage, tolerance & modifications
- Establishing a level of comfort for current project and future ones too

… so YES, worth the trip!





Thank You

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