Effective interface management for complex cladding projects: UOB Plaza, Singapore

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SUMMARY

The UOB (United Overseas Bank) Plaza 2, Singapore, was one of 15 case projects used to study interface management in research funded by the UK's Engineering and Physical Sciences Research Council (EPSRC). The major finding is that problems in large scale complex buildings are more likely to occur at the interfaces between components or elements of the building. This is particularly true for elements such as high performance, bespoke designed cladding, and affects design development, construction and long term performance of the building. The key to improvements in the efficiency of building design and construction lies in the area of interface management. This paper presents the UOB Plaza case study, describing the key interfaces and interface management aspects.

KEYWORDS: Management, Cladding, Interfaces, Major Projects

INTRODUCTION

Problems on complex building projects are concentrated around the interfaces between components and elements of a building. The way that these interfaces are managed will affect the outcome of the project. This paper describes the interface management during the design development of the cladding on the Plaza 2 project in Singapore, in the context of a recently completed, two-year, EPSRC-funded research programme entitled "Testing Methods for Construction Interfaces." Further information on the Plaza development has been presented at a recent CIB conference in Beijing [1], and other aspects have been published elsewhere [2,3,4,5,6].

RESEARCH HYPOTHESIS, METHODOLOGY AND RESULTS

The research hypothesis is that the key to improvements in the efficiency of building design and construction lies in the area of interface management. By concentrating on interfaces, weaknesses in design and construction should be identified, leading to improved standards of detailing and workmanship.

Fifteen case projects, which all incorporated complex external cladding, were studied by: interviewing key project personnel; visiting the sites and cladding works; witnessing prototype test; and obtaining project documentation.

The following main conclusions were made:

Interface problems
Problems on complex construction projects become concentrated around interfaces.

Interface tolerances
Tolerance issues at interfaces, particularly with the building structure, cause major problems and must be adequately considered at an early stage.

Interface culture
Different trades have different cultures, with different attitudes to tolerances, damage and interface responsibility.

The followings are the key recommendations for effective interface management of the building envelope. However, they can also be applied to other building elements:

Proper interface consideration
This is essential for effective management of the design development, testing and construction phases. Failure in this area will lead to poor coordination on site, contractual conflicts and future problems with the works.

Early involvement of all the major players
Effort invested at the early stages of the project, particularly early design development, will reduce the problems encountered later.

A proactive interface strategy
A positive, proactive and open attitude to interfaces from the whole project team improves constructability and productivity on site. A strategy to exploit the expertise of each party must be agreed at an early stage.

THE UOB PLAZA 2 PROJECT

The UOB Plaza Development (Figures 1 and 2) comprises: Plaza 1, a new build 66-storey tower; and Plaza 2, a major refurbishment of 44 stories originally constructed in the 1970s.

The developer and primary occupier is the United Overseas Bank (UOB), the architect was Singapore-based A61, and main contractor was the Wimpey Woh-Hup joint venture (WWH). Plaza 2 was completed in 1995 and cost around US$ 65 million. The top section of the building was completely removed and three new floors and a plantroom were added. The original cladding was precast concrete with aluminium windows, which was completely removed and replaced with a granite-clad, metal and glass curtain wall, by Permasteelisa, to match Plaza 1. There is a large glazed entrance canopy by Grill and Grossmann (GIG).
cladding from different suppliers
- With add-on sections or features [7]
3. Vertical cladding / 'Horizontal' roofing or paving
4. Cladding / internal works
- With building services
- With raised floors and suspended ceilings
- With partition systems

These areas were investigated for the cladding on the Plaza 2 project, with the main issues in order of significance being:
- Existing building interface
- Internal works interface (mainly due to existing building problems)
- Glazed canopy interface (multi-trade)
- Flat roofs interface (multi-trade)
- Plantroom cladding (multi-trade)

Figure 3 – Main cladding fixings post-fixed to the top of the concrete slab

Main wall cladding interfaces with the existing structural frame
As is common on refurbishment or re-cladding projects the original building structure was quite badly out of position (~100mm twist). This twist had to be built into the fixings for the new wall cladding. After the demolition of original cladding the existing frame was surveyed and the fixings designed to suit, allowing for a 230mm cladding zone (Figures 3 and 4).

There was a large provision for movement - basically the settlement of the new umbrella truss on the upper floors. The contractor had to load the upper floors with sand and cement, before the cladding was fixed to try and make the structure deflect the projected 25 to 50mm. However, the deflection did not occur and this caused problems at the set backs at

Figure 4 – Wind load fixings welded to the underside of the edge beam

COMPARISON BETWEEN GENERIC INTERFACE PROBLEMS AND THE PLAZA 2 EXPERIENCE

From the main research and other experience the major building envelope interfaces that create difficulties and challenges for project teams fall into four main categories:
1. Structure / Cladding
   - With the existing structure (for over-cladding, re-cladding or retained facades)
   - With the new structure
   - With adjacent buildings
   - With secondary support steelwork
   - With retained historical facades
2. Multi-trade interfaces
   - Between various different cladding types, or similar
high level, where the cill member was slotted to accept the cladding above.

Two of the other case projects in the EPSRC study involved new cladding of existing structures, namely Camomile Street in London and IFF in New York. Camomile was a strip down to base structure and re-clad with an 'exact' replica of the original cladding following terrorist bomb damage. As for Plaza 2, the existing structure was significantly out of position in places, requiring considerable remedial work before recladding could commence. IFF was a simpler structure and brick which was to be overlaid with metal and glass curtain wall to create a new image. The original structure was out of position however, because a considerable time was allocated to install the fixings and the overcladding was to be fixed to the outside of the original cladding, the problem areas were identified and solutions agreed without delay to the overall programme. This experience suggests the need for accurate 'as-built' drawings following construction including identification of areas built 'out of tolerance'. However, the 'blame-culture' that prevails in construction usually results in problems being hidden by contractors to prevent cost deductions or litigation. These issues must be addressed as refurbishment is becoming a major sector for construction in the developed world as many buildings reach the end of their useful lives.

Recent developments in Europe, such as the Health and Safety legislation emanating from the Temporary and Mobile Construction Sites Directive (The UK's Construction (Design and Management) Regulations - CDM), are directing project teams to consider the future main refurbishment, reuse and deconstruction of buildings during design. It is also a new legal requirement in Europe to compile full record documents of all design and construction decisions, especially where they vary the as-designed building. The drivers for this legislation are obviously the health and safety of current and future workers. Nevertheless, this more holistic view of construction could encourage a more open attitude towards accurate as-constructed records, and this would reduce the time and additional costs during refurbishment resulting from unforeseen problems with existing structures.

**Main cladding interface with internal wall linings, floors and ceilings**

Once the cladding was installed the internal wall lining was fixed by another subcontractor, terminating at a pre-fixed angle on the cladding. This interface allowed for minor movement at this junction. The twist in the structure caused some of the linings to be out of line with the cladding opening, resulting in the need for some dog-leg rebates in the reveals.

Plaza 2 had a 20mm nominal floor screed rather than a raised floor. Therefore the floor and ceiling interface was critical in terms of level, but tight control prevented problems despite the spatial constraints. First the blind boxes and window surrounds were installed then determining the line of the internal dry wall and ceiling. The suspended ceiling followed around, connected onto the blind box and the column.

**Glazed canopy interfaces**

Plaza 2's 26.3m x 36.3m glazed entrance canopy comprised a series of fully welded, tubular stainless steel trusses cantilevering out from the main building (Figures 5 and 6). The galvanised bracket detail was developed following site measurement after the removal of the existing cladding. The construction process for the canopy was:

- fire protection to structural steel removed (GIG);
- canopy trusses set out to datum (GIG);
- brackets installed (GIG);
- cladding panels installed (Permateelisa);
- trusses installed (GIG);
- infill stonework fixed (Permateelisa);
- silicone seal gap around bracket (Permateelisa).

There was a planned clearance of 15mm around the brackets through the cladding, but it ended up around 25-30mm (Figures 7 and 8).

The main raking tie connection at level 8 was designed by Ove Arup (Figures 5 and 9). The galvanised steel strip goes round the perimeter column then back to the core at floor level with a steel plate going up the face of the core to ensure that the load is adequately distributed.

There was a gap left at the bottom of the cladding for GIG to install a stainless steel gutter for the canopy, then underneath the gutter Permateelisa installed a flashing piece. The main issues here were agreeing a common line and level and watertightness - especially at the gutter. The principle was for one party to be responsible for the watertightness - therefore the flashing and weathering was by Permateelisa.

The electrical subcontractor had to route cables from the building, though the trusses via conduit, to lights under the canopy. GIG met with this subcontractor to agree the conduit routes which were fixed off site with draw wires before the trusses were fabricated due to access problems after installation.

![Figure 5 - Inverted glazed canopy to Plaza 2 - main structural hanger shown at the top centre](image)

**Interface with plant room cladding at roof level**

The high-level plant room enclosure comprised cold-rolled purlins fixed to a main frame with profiled metal cladding, each provided by different contractors. There was a two-stage weather seal with a stepped flashing at the top which steps over the curtain wall and then a cosmetic stainless steel coping. All the work was completed by Permateelisa including the final flashing, with the plant room cladding just tucked in afterwards. This is a good example of a subsequent interface [5] where the different trades are separated such that only one handover between them is required, rather than an iterative interface requiring a series of inter-dependent operations by each trade.

**Interface with the stepped roofs at high level**

There are a series of flat roof step backs at the upper levels of the building as the floor plate reduces in plan (Figure 10). The flashing was by Permateelisa, but the water proofing to the roof was by the main contractor. Some problems were encountered
both with design development changes of the cladding interface and the structural deflection issues discussed earlier. Permasteelisa added that in some cases remedial works were required to the concrete upstands after the main wall cladding had been fixed. The project team accepted that sometimes the pressure of progressing the works at the expense of obtaining the correct interface detail becomes a commercial reality. Notwithstanding, appropriate remedial works were completed and the detail amended.

COMPARISON BETWEEN GENERIC INTERFACE MANAGEMENT AND THE PLAZA 2 APPROACH

Meetings to develop interface design
On most of the EPSRC projects interfaces were developed at face-to-face meetings between the architect and the combined subcontractors. On Plaza 2 these were very intensive meetings, at least once a week and involving several subcontractors at a time.

Often informal meetings are encouraged to foster a team approach, and some of these would be social events. GIG's Byrne stressed that it was agreed at the start of the project that anything agreed directly between subcontractors had no contractual significance because the main contractor had not sanctioned it. This tended to dissuade the practice of ad hoc meetings between specialists. With the exception of a topping out ceremony
meetings convened for social purposes were not part of the UOB strategy.

Byrne explained that, in Singapore, it is common for the client to get more involved and ask to see the specialist contractor informally. Byrne stressed that he would always invite the main contractor to attend these meetings. In Singapore, company directors only seem to get involved in the projects if there are difficulties.

The interviewees identified key issues to ensure meeting effectiveness as:
- a clear agenda and objectives;
- a required performance;
- good time keeping;
- keeping to the point;
- developing and maintaining a positive attitude; and,
- problem solving not fault finding.

Design development and drawing strategy
Most of the case organisations appointed a design development coordinator to ensure that the interfaces were properly considered.

On UOB the tender drawings indicated the scope of the works and formed the basis for design development. The cladding contractors were given a survey of the existing structure but GIG supplemented this with their own.

On the EPSRC projects opinions were divided regarding the benefit of full interface drawings, who should produce them and how they should be distributed. On UOB Permasteelisa drew complex interfaces in detail and sometimes added explanatory method statements and GIG included Permasteelisa’s cladding works and the flashing on their canopy gutter drawings to assist in working out the interface. Officially, subcontractors issued six copies of everything to WWH for distribution. However, to expedite design development they issued one copy direct to interfacing subcontractors.

Fixing into or between cladding systems
Because of the complex nature of cladding elements on large buildings there is often the need to fix items onto the cladding or connect two different systems together. This can create problems with responsibilities and warranties at the interface. The over-riding principle on Plaza 2 was that fixings were not allowed into the cladding. The canopy trusses were fixed back to the structural steelwork through the main cladding but did not connect to or touch the cladding. The internal gyproc wall linings were supported by an independent metal stud system.

Specific performance testing of construction interfaces
UOB specified performance tests on the building facade, in line with contemporary good practice for high rise buildings costing around US$ 140K-210K[2]. The mock-up sample for Plaza 1 was tested in Australia and included a corner section which is one of the key in system interfaces. Lim explained that they “chose a section that represented the typical situation, inclusive of the window and interfacing with the floor, large enough to include all relevant aspects such as a corner. There were no intra-track interface tests on UOB, for instance the actual fixing brackets were used but the flooring was represented by steelwork. Again opinion is divided on this issue but for UOB Cheung considers that interfaces were insignificant compared with the 66 stories.

Lim stated that UOB is a difficult building to go back and do remedials because of high-level access, thus emphasising the need for effective testing. Client Lau claimed that he would support similar tests on future jobs adding that, although every job will be different, it is the edges and corners that cause the problems not the main panels. He believes that you can calculate lots of things, but if you test then at least you know that before you installed it then it was okay, rather than to put it up and then find that there are problems.

CONCLUSION
The UOB Plaza team supports the view that problems can be concentrated around interfaces, and effective interface management is a necessary ingredient for successful project management. UOB’s Lau (who has authored a book on project management [8]) agrees that there are interface problems, not just on cladding, but with air conditioning, electricity, ceiling finishes. Lau’s philosophy is that you should get rid of your problems by solving them early, rather than letting them hit you on site - “you can not solve everything for a big project, but you must try.”

The project team adopted an interface management strategy throughout the design development stage which includes individual responsibility, face-to-face meetings, drawing; management, fixing restrictions and appropriate performance testing.
REFERENCES


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