# SOME VICTORIAN EXAMPLES OF STRUCTURAL BRICK MASONRY

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ABSTRACT:

A number of examples of the use of diaphragm walls and reinforced brickwork and the construction problems experienced during the building of these projects are given in this paper.

Introduction:

In the late 1970's our office had a number of gymnasiums, multi-use halls and churches to design. All of these were high, single-storey brick buildings with few internal walls. As we progressed through the designs for these buildings it became apparent that the use of the brick cladding as a structural element in the buildings would result in savings and give structure that had a rigidity that matched the rigidity of the cladding.

St. Leonards College Multi-Use Hall

The first of these buildings was St. Leonards College Multi-Use Hall. This was designed as a conventional braced steel framed building with brick clad walls. Because the architect wanted to avoid the columns projecting into the hall, the building was designed with very wide cavities (180mm) with the steel frame buried in the wall. During the design we were concerned about the mating of a relatively flexible steel frame with rigid brick walls. The use of a braced frame structure instead of portal frames kept the deflections fairly small, but under full wind load cracking of the brickwork would still occur. During the design of the building we became aware of the work in the U.K. on diaphragm walls and felt that this building would have been an ideal application for this technique, unfortunately the design was too far advanced at that stage to change.

Church of Jesus Christ of Latter Day Saints - Epping

Shortly after completing the design for St. Leonards we were asked to design the structure for a church at Epping for the Church of Jesus Christ of Latter Day Saints. Here like St. Leonards we used a steel frame but utilized the brickwork to stabilize the building. Slender C.H.S. columns were used to support the roof steel and to enable it to be erected before the brickwork. Temporary bracing provided the stability until the brickwork was built around the columns and the cavity grouted. This building also contained reinforced brick lintels and a reinforced brick spire 14 metres high.

Church of Jesus Christ of Latter Day Saints - Wantirna

Later the same year we started the design of a larger church at Wantirna for the Church of Jesus Christ of Latter Day Saints. The requirements were for large single-storey open spaces, brick walls, a spire 20 metres high, in addition large openings were required between the various parts of the church to enable the building to be opened up for special occassions. The church was to be built by members of the congregation.

It was decided to use diaphragm brick walls and reinforced brick piers to support the roof structure and eliminate all steel columns, bracing and horizontal steel members that would be required to stabilize cavity brick walls. Part of the design requirements was to support a 5 metre high brick wall over an opening 15 metres wide.

See Figure 1 below:

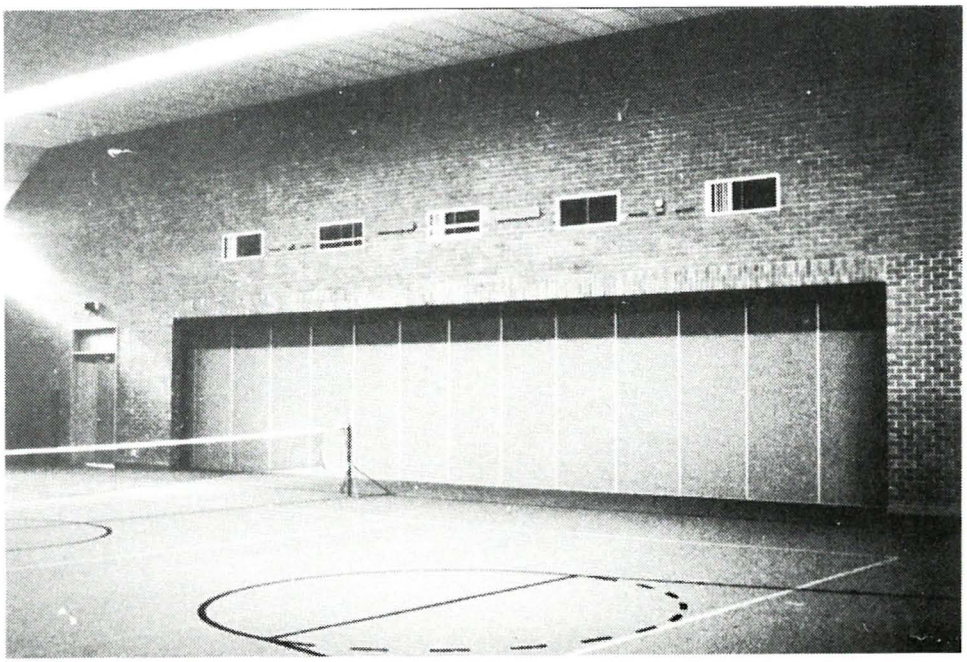

Figure 1 Opening in Wall between Chapel & Hall

The alternate methods of supporting the brickwork were using a fabricated steel beam, which would have required special strengthening to prevent lateral instability of the top flange, using a deep reinforced concrete or prestressed concrete beam, neither of which were aesthetically acceptable or to design the wall as a reinforced brick beam. This latter method was adopted for this and for a shorter 11 metre opening.

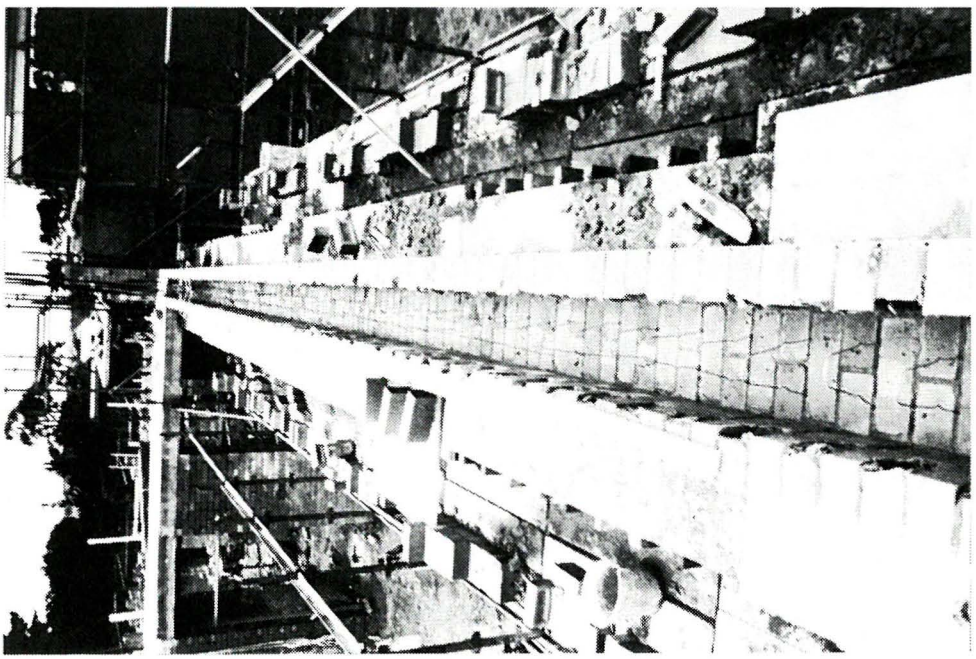

Figure 2. Commencement of Construction of 15metre Brick Beam.

Bonegilla Army Development - Mess Recreation Building

During the same year we started the structural design for a Mess and Recreational Building for the Army's new apprentice training school at Bonegilla. Included in the building complex were three squash courts a gymnasium and a weight lighting hall all of which were suitable for the use of of diaphragm walling and after some initial doubts by the Architect about weather tightness of the building the diaphragm wall solution was adopted.

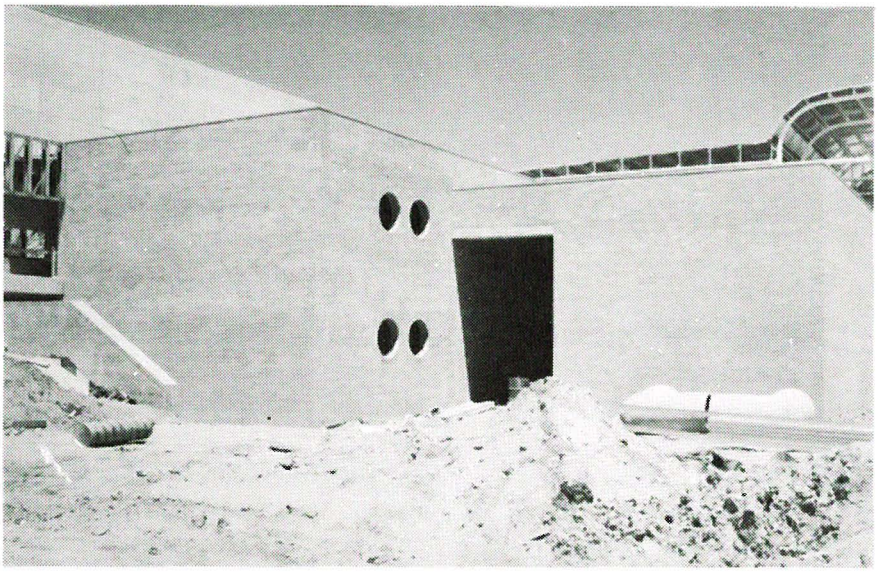

Figure 3. Weight Lifting Hall and two-storey offices - Bonegilla

Grovedale Catholic Parish Centre

In 1981 we commenced the design of a Catholic Church at Grovedale. Again there was a requirement a tall single-storey brick building with no internal walls, but with the added complications that one whole wall was to be glazed. The roof structure of the building was unusual in that it used externally exposed steel trusses in the shape of a cross. Because the architectural design had some buttresses we suggested the use of finned walls to give stability to the building, but this was not architecturally acceptable. We eventually designed the walls as diaphragm walls but with the one glazed side it was necessary to put reinforced piers within the thickness of the walls to take the thrust from the ring beam at roof level.

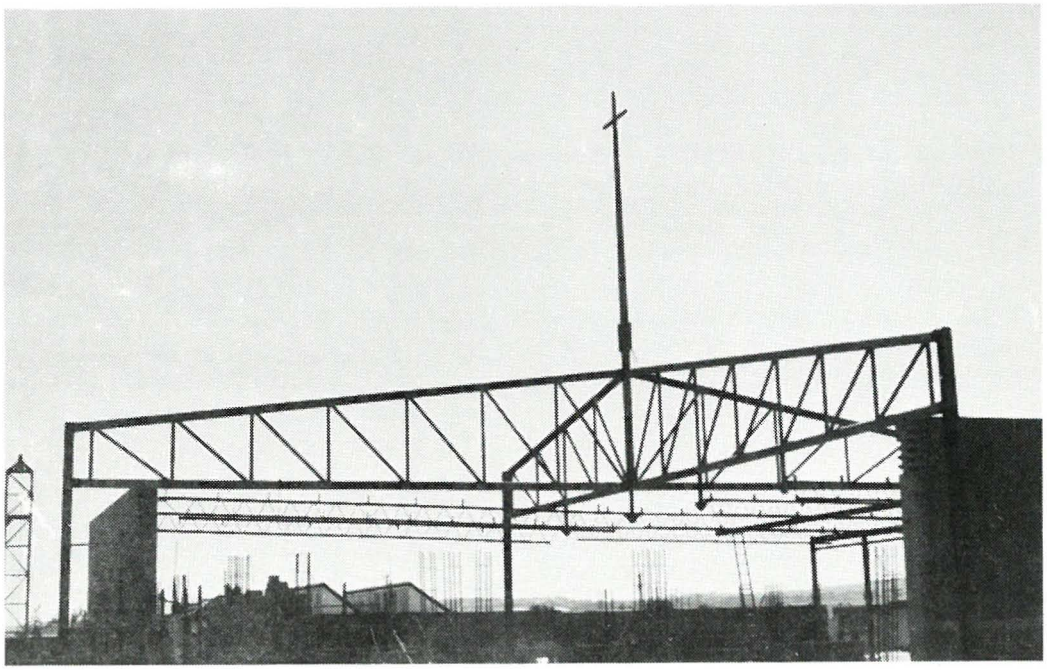

Figure 4. Grovedale Church Steelwork.

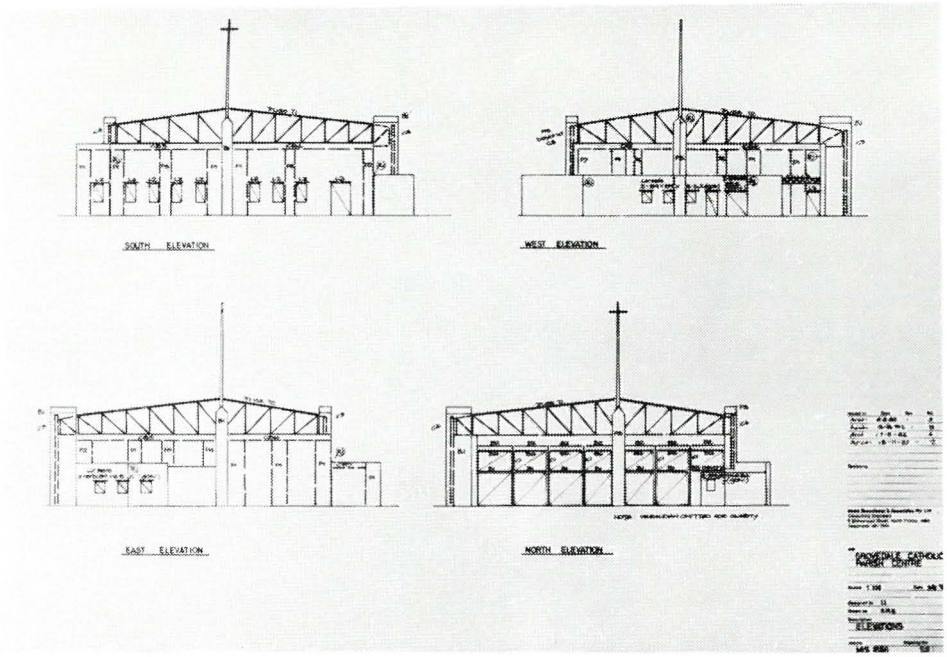


Figure 5. Wall Elevations Grovedale Church

Figure 5 shows the wall elevations of the church, P1, P2 etc., being the cantilever reinforced brick piers and CB1, CB2 etc., being the ring beam at the top of the walls.

Infill Housing - Carlton

The latest architectural fashion "Post Modernism" has also created an opportunity to use reinforced brickwork.

Coinciding with the rise of post-modernism has been the change in the Ministry of Housing policy away from slum clearance and high rise buildings to infill housing and restoring the present housing stock. Many of the infill houses have been designed for the Ministry of Housing by private architects and much of the housing is post-modernist in external appearance. To stabilize the high parapets, stepped brickwork over openings etc., it has been necessary to use reinforced brickwork for a number of these houses.

Figure 6. Entrance to a Pair of Infill Houses.

Victoria College Library - Burwood Campus

The Victoria College Library is also a post-modernist building and here again reinforced brickwork was used to advantage. The building is located on a sloping site and preliminary design indicated that the cheapest form of construction for the ground floor was to use compacted fill behind a retaining wall with a floating concrete slab on the fill. As the building was brick clad it was most economic to design the retaining walls as reinforced brick walls with vertical reinforcement in pockets at 1.2 metre centres and galvanised horizontal reinforcement in the bed joints. Reinforced brickwork was also used to support the brickwork over the more unusual openings.

Construction Problems

In all these examples it was necessary to educate the bricklayers and site foreman in the special requirement of structural masonry.

For the Church of Jesus Christ of Latter Day Saints at Wantirna preconstruction testing was carried out and the requirements of the structural brickwork carefully explained. A testing programme was instituted to check the crushing strength of the mortar and brickwork and the bond strength of the brickwork. Results of this testing were all excellent.

The one problem we did encounter on site was when the 11 metre brick beam was being grouted a blow out of the brickwork occurred. This blow-out was due to several factors.

1. Z ties tying the two skins of brickwork together were fabricated too short and were not adequately bonded into the walls and these ties failed in bond.

2. The over enthusiastic use of a vibrator created excess pressure at the time of grouting.

3. The grout was pumped into the top of the cavity and considerable forces were generated by the impact of the grout at the bottom of the beam.

Larger ties were installed, grout was placed by barrow not pumped grout lifts limited in height to 1.2m and no further problems were encountered.

At Bonegilla we were not responsible for the supervision and despite a tightly written specification the initial brickwork was not built as specified. No pre-construction testing was carried out to resolve problems with the brickwork and when the site was visited after construction had started a number of faults were discovered.

1. Wire cut bricks were being used instead of solid pressed bricks.

2. Perpends were not adequately filled.

3. The mortar joint between the diaphragm bricks and the face bricks not properly filled.

4. Wrong ties being used in the diaphragm walls.

5. Shovel batching of mortar and additives used in the mortar.

6. When the first bond-beam was lifted to be tested it fell apart and the other bond beams tested failed at bond stresses of Ø.1 and Ø.13 MPa instead of the minimum specified of Ø.28MPa.

Work on the brickwork was stopped and a series of tests were carried out by the B.D.R.I.

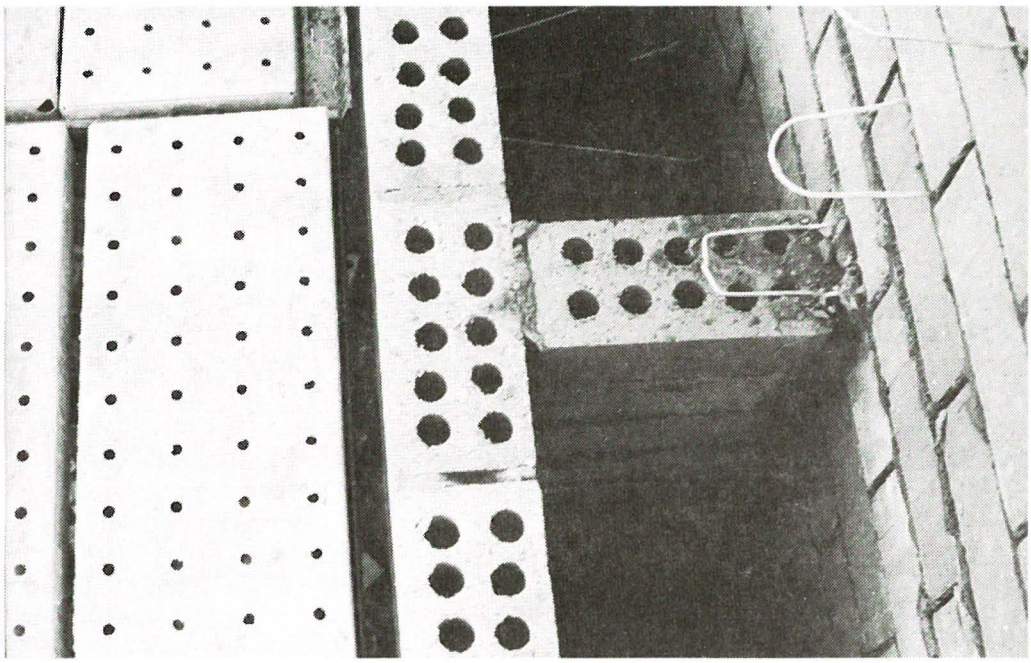

Figure 7. Diaphragm Wall with incorrect ties and perpends not filled.

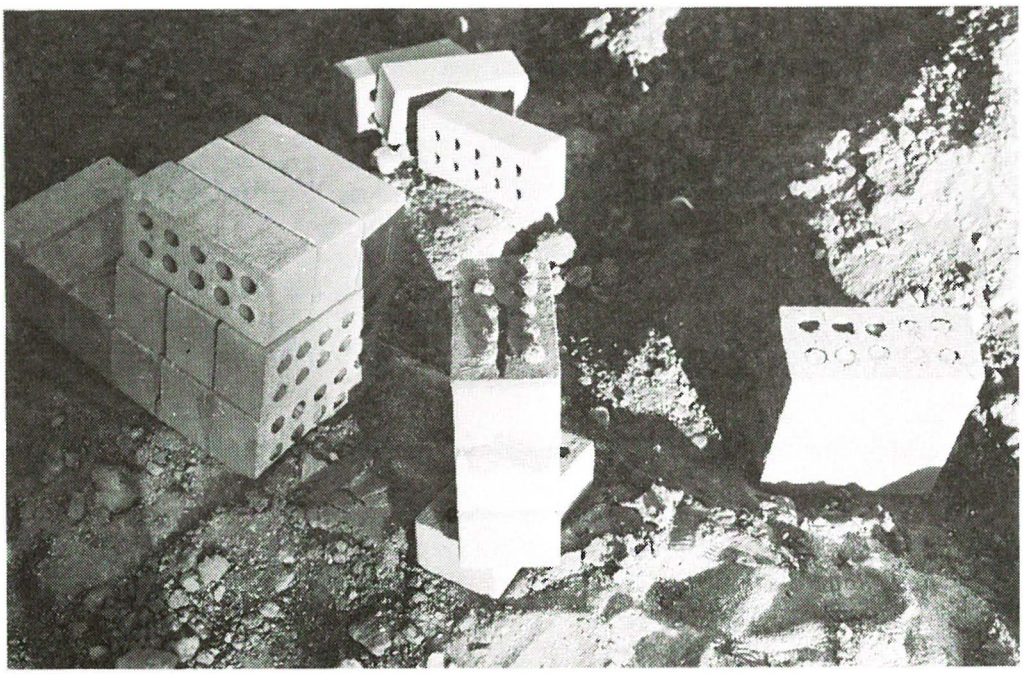

Figure 8. Failed Bond Beam.

The failed bond beams were tested using the B.D.R.I. bond wrench, different mortar mixes were made using the various sands available at Bonegilla and a test was devised to check the effect of not having the joint between the diaphragm bricks an the outer skin completely filled. Tests were also done to evaluate the effect of ties on the strength of the joint.

The ties did not add to the strength of the joint but did give post cracking strength to the joint. It was found that the post cracking strength could be predicated from the bending strength of the tie treated as fixed at each end and bending over a 10mm length.

Tests on the mortar sand resulted in changes to the type of sand used in the mortar and the bond beams tested on site once the job re-commenced gave strengths in excess of 0.4 MPa.

At the Grovedale Catholic Church no major problems were experienced with the brickwork. The bricks used had a higher rate of absorption than specified which necessitated extra preconstruction testing to ensure compatability of mortar and bricks. During the course of construction some variability was experienced in the bond beam testing which was traced to the builder using additives in the mortar and re-tempering the mortar. Once these practices were eliminated bond beam strengths of 0.49 MPa and higher were regularly obtained.

At Burwood State College Library brick strengths were less than specified and less than the strength given by the manufacturer fortunately the design of the retaining wall was sufficiently conservative to cope with the lower strength. Bond beam strengths obtained were all in excess of 0.28MPa.

Conclusions

Structural brickwork requires as much or more supervision as reinforced concrete and until bricklayers and site foreman are familiar with the special requirements of structural brickwork preconstruction testing and on-site testing should always be carried out to ensure that the desired results are obtained. Supervision of structural masonry should be by someone familiar with the special requirements of structural brickwork, preferably the designing engineer.