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A SURVEY OF EXCAVATIONS & THEIR SUPPORT

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INTRODUCTION

With the increasing density of urbanisation in the larger cities of Australia, commercial buildings now usually incorporate substantial excavations for carparking and other facilities below the ground. In addition, the building height limitations now often being imposed by Local Councils (to prevent the overshadowing of other buildings, parks, public spaces, etc.) has meant that economic development of the more densely populated business districts of our Cities can usually only take place by constructing a number of basements. These basement structures are often close to, or adjoining other major buildings and streets; the excavations are also of a size that pose quite considerable design and construction problems.

Therefore, and to enable further development of improved excavation techniques and support systems, Shirley Partners Pty. Limited undertook a 'state of the art' survey of a number of building excavations and their methods of support. The results of this survey are presented in this paper together with comments as to some of the factors disclosed by the survey.

DESCRIPTION OF SURVEY

As the survey was seen to be a technical 'information gathering' exercise, it was decided to direct mail a cross-section of those persons perceived to have had some significant involvement in substantial building excavations. The survey was mailed to Architects, Contractors, Consulting Engineers and Local Government Authorities and asked questions in a format which required simple, 'tick box' answers.

Of the 230 survey forms sent out, 23 organisations responded and provided data upon some 30 excavation sites.

The responses according to participant type were as follows:

Architects	3%	Engineers	16%
Contractors	17%	Government	10%

Although the overall Governmental response was 10%, several Officers of State Government Departments and Local Councils discussed the matter extensively with Shirley Partners Pty. Limited; therefore, the Governmental interest in the survey was considered to be much greater than the statistical response indicated.

The survey form included many questions pertinent to the development, size of excavation, adopted method of support (both permanent and temporary), as well as information upon the advice sought by the developer prior to undertaking the excavation. The survey also extensively probed information upon problems that might have occurred with the excavation and the adopted support system.

The results of the survey were then analysed using a standard database programme and the statistical analysis forwarded to the survey participants. Two anonymous returns were supplied which included some significant comments as to the efficacy of the engineering advice provided to the Contractor, as well as some strong remarks about the suitability of the excavation support system designed. The majority of the survey returns also included remarks as to ways in which excavation support methodology could be improved, with some participants making specific suggestions as to how the site investigation and engineering of the support system should have been carried out.

RESULTS OF SURVEY

In this paper it is not intended to present the full statistical analysis, but rather a series of comments upon the salient features that emerged from the survey forms returned. These are discussed in the following paragraphs:

1. Site Investigation & Geotechnical Advice

Ninety percent of all sites surveyed had a Site Investigation undertaken prior to the construction of the development, with some 40% of investigations being undertaken before the development plans were prepared. However, nearly 50% of the Site Investigations were undertaken during the course of preparing the engineering plans and these sites appeared to have the most problems.

The Report prepared by the Site Investigator usually provided advice upon a wide range of matters, with 67% of survey responses indicating that the report advised upon matters other than the 'foundation design'. The matters advised upon included earth pressures, soil & rock design parameters, stability of excavation, groundwater, excavation zone of influence, methods of support for the excavation, excavation methodology, underpinning of adjacent structures, etc. However, whilst 77% of all Site Investigations were carried out by a 'Specialist Geotechnical Consultant', only 17% of the sites had boreholes drilled outside of the area to be excavated (i.e. within the materials requiring support or contributing to groundwater problems).

2. Geology

When the survey questionnaire was developed, a number of questions were included upon the geological conditions evident at the site, as it was felt that poor geological conditions would lead to considerable excavation support problems.

However, the survey returns did not provide any definite correlation between the site problems experienced and the evident geological conditions. Further, a number of problems occurred in excavations within the Hawkesbury Sandstone (30% of excavation sites); at these sites, a 33% failure rate was recorded in both the temporary support and damage to services.

Therefore, and as the Hawkesbury Sandstone is perceived to be a strong material requiring little or no support, it would appear that the Contractor's 'perception of a problem' is most important in determining whether or not a problem arises. It would also appear that when excavations are planned in filled and alluvial areas (10% of cases), extensive advice was sought because many problems were envisaged. Consequently, a similar problem rate occurred at both simple and difficult geological sites.

3. Systems of Excavation Support

The survey format was designed to encompass most of the systems currently in use, including timber strutting, steel soldiers, shotcrete, contiguous walls, sheet piling, stressed and passive anchors, and slurry wall techniques.

The survey showed that whilst 33% of sites were supported with 'steel soldiers and timber' the other methods of support were used evenly.

Stressed strand anchors were used to 'tie back' or 'anchor' the temporary support system in 40% of cases, whilst anchors were not used at 40% of sites.

On a number of sites the excavated face was left unsupported without any battering back and several comments were made that the Contractor was 'prepared to take the risk'. As a number of failures subsequently occurred in these excavations (principally in residual clays and weak shale materials) which then affected streets, services and adjacent building structures, this 'taking of risk' by a Contractor has wide ranging community and insurance ramifications.

4. Failures of Excavation Support

Whilst a failure of an unsupported excavation was apparently regarded as an 'acceptable risk', relatively small movement of the temporary support system was not generally accepted. Some 17% of excavations reported significant (i.e. greater than 20mm) movements into the excavation and these movements often caused problems during the construction of the permanent structure. In some cases the movement of the temporary support was very large and resulted in a failure of the excavated face over a significant area; consequently, significant repairs were required to the nearby streets and adjacent building structures.

Due to the wide range of excavation support methods used, it was not possible to correlate failures with a particular support technique; however, it was evident that the extensive groundwater inflows that were recorded in some 37% of sites must have had a very significant bearing upon the failures of the temporary support system. It is also noted that whilst the groundwater problem was generally identified by the Site Investigator (in 57% of cases) when the groundwater problem actually occurred (37% of cases) the problems and difficulties had not usually been provided for.

5. Permanent & Temporary Support of Excavation

The survey sought to identify the number of excavations in which the permanent support system was used in conjunction with the temporary support system; in some 37% of cases the permanent support was designed to incorporate the temporary support into the final building structure.

When the severity of the excavation support problems were correlated to the integration of temporary and permanent support, it was found that very few severe problems occurred with an excavation in which the permanent support was designed to be incorporated into the temporary support.

6. Statutory Authority Involvement

Because the majority of excavations extend to, or very close to, the property boundaries, the Local Council is normally both involved and affected by the activities of persons undertaking excavations. Further, the Council would also appear to have a responsibility to take 'due care' when it reviews any plans or details of excavation support submitted for approval.

In regard to roads, services and nearby buildings, because the Council is often charged with the maintenance of such structures (e.g. repairing stormwater pipes, etc.) it is in the Council's interest to ensure that an excavation does not damage such services or structures. Further, and because many of the larger excavations have a large 'zone of influence' (which can extend to and beyond buildings on the opposite side of the road) a Council frequently becomes involved in the complaints and actions by road users and property owners.

In addition, as the Department of Industrial Relations administers the N.S.W. Construction Industry Safety Act which in effect requires that all excavation support systems be approved by the Department prior to utilisation on a specific project site, the Local Council would be well advised to ensure that the approval of the D.I.R. has always been obtained for a particular system before it is used at a particular site.

Therefore, and as a number of Engineers may be unaware of the Department's requirements, it would appear appropriate for the Local Council to ask a number of questions prior to approving, or consenting to an Application to undertake an excavation at a particular location; such questions could possibly include:

a) What effect will the proposed excavation have upon the nearby or adjacent buildings, roads and services?

b) Will the support system proposed (including no support) adequately maintain the support of the nearby and adjacent buildings, roads, services and other structures?

c) Does the excavation support system proposed comply with the N.S.W. Construction Industry Safety Act?

It would appear that unless the Local Council is satisfied with the responses to these questions, then the excavation should not be permitted until an acceptable support system design is provided.

CONCLUSIONS

Whilst the Excavation Support Survey confirmed a number of the pre-existing views, it also brought to light a number of factors which had not been previously suspected. These new factors were:

1. The wide use of Specialist Geotechnical Consultants to undertake site investigations and provide advice upon the various aspects of an excavation (including its support and possible problems). Hitherto, it had been suspected that the role of the Specialist Geotechnical Consultant was rather limited.

2. Whilst specific advice was often provided, it was sometimes misunderstood or not appropriately implemented.

3. The problems that occur with excavations are almost independent of the geology, but closely related to the 'perception of a problem', (i.e. if you suspect and plan for problems, they don't happen!).

In addition, a number of other conclusions emerged from the survey:

1. A very wide range of excavation support systems are being adopted for apparently similar geological conditions, with a large number of sites still utilising conventional 'steel soldiers and timber' methods of support.

2. Developers and contractors apparently do not appreciate that steel soldiers and timber are inherently 'soft' systems of support, and can deflect considerably.

3. The failure rate of Temporary Support Systems is unacceptably high - 47% of all installations surveyed. (Note: Whilst this failure rate may in fact not be as high as this due to the bias of the sample, the excavations surveyed did represent building construction over the last 3 years in N.S.W.).

4. As the most severe problems occur with a Temporary Support System that is independent of the Permanent Support System, it would appear that a greater appropriate engineering input is required into the design of temporary support systems.

5. Site Investigations need to be extended to include probing of the materials to be supported, as well as the materials that are to be excavated.

6. Because a Local Council will usually always become enmeshed in any legal disputation that follows a failure in the materials surrounding the site, the Council needs to very carefully consider all the engineering details of excavation support systems and require persons seeking approval to submit full documentation of the support system in compliance with the N.S.W. Construction Industry Safety Act.