

GUIDELINES FOR
GEOTECHNICAL INVESTIGATION OF
BRIDGE STRUCTURES

Materials Engineering
Report No. 2009-8M
(Supersedes Report No. 21)

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ABSTRACT

This guideline has been prepared to assist in the planning, cost estimation, conduct and reporting of geotechnical investigations at Main Roads Western Australia (MRWA) bridge sites. The objectives for these guidelines are to describe the processes or stages of work to be followed for a bridge site investigation. It also describes the information required to design bridge foundations. The guideline also indicates standard of skill, workmanship and reporting to be applied in the investigation process. A flow chart summarising the processes involved in the site investigation is included in the Appendix A of the guideline.

This guideline document should be used as a guide and not approached or referred to as a limiting or standard geotechnical investigation/design specification.

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APPENDIX A: FLOW CHART ON GUIDELINES FOR GEOTECHNICAL INVESTIGATIONS
FOR BRIDGE STRUCTURES

1. INTRODUCTION

This guideline document has been prepared to assist in the planning, cost estimation, conduct and reporting of geotechnical investigations at bridge sites. Henceforth for ease of reporting, reference is made only to requirements at bridge sites however corresponding requirements at waterway structures are implicit in this term.

2. OBJECTIVES

The objectives for these guidelines are to:

- Describe processes or stages of work to be followed for a bridge site investigation.
- Describe information required to design bridge foundations.
- Indicate standards of skill, workmanship and reporting, which are to be applied.

A flow chart summarising the processes involved in a bridge site investigation is included in Appendix A.

3. STAGES OF INVESTIGATION

3.1 Field Reconnaissance Survey

For most bridge investigations access and environmental constraints have major influences on cost. It is therefore necessary for a field reconnaissance survey to be conducted as the first stage of a geotechnical investigation. This may be undertaken by MRWA or by a consultant specifically engaged for this survey. Information on the following should result:

- Legal and physical aspects of access to site and bridge alignment – both riverbed and adjoining properties.
- Availability of any services or supplies of water, electricity, earthworks plant.
- Buried or overhead services.
- Photographs of surface conditions.
- Traffic control requirements.

- The possible effects of alternative investigation techniques on the environment (for example, ground disturbance, vegetation removal, water discharge, noise etc).
- On-ground survey details.
- Tide, river level or other natural constraints.
- Notes on any exposed geology, for example the presence of boulders, bedrock exposure, swamps etc.
- The physical relationship of the proposed construction to the immediate natural surroundings and any existing developments.

The field reconnaissance survey must be diligently prepared and conducted to allow for reliable cost estimates to be prepared. Experienced and suitably qualified personnel should perform the survey. Further stages of the investigation should be held until the field reconnaissance survey has been completed and reported to MRWA. Cost estimates for the major part of the investigation will be based partly on this reconnaissance survey.

3.2 Desk Top Study

Every site investigation should commence with a desk study directed towards collecting, collating and reviewing the following:

- Design drawings from any previous structure at the site.
- Previous site investigation reports, borehole logs, penetrometer results and construction experience e.g. piling records.
- Geological and Topographical maps, survey data and records.
- Hydrological data.
- Aerial photographs.
- Regional seismicity data.
- Survey records, local knowledge and resources.

The collection and collation of the above information, where possible, could be undertaken during the field reconnaissance survey stage. However, further work to fully explore the extent of information available may be required.

During the desk study stage, an overview of complexity and risks associated with each geotechnical design should be clearly identified.

3.3 Sampling and Testing

This stage of the Geotechnical Investigation is involved with the exploration of subsurface conditions and retrieval of test data for generating geotechnical parameters and geotechnical profiles.

Central to the investigation and subsequent design stage an understanding of the ultimate limit state design to be adopted for design is an essential. This should be done by a suitably qualified and experienced geotechnical engineer and conveyed to the personnel conducting the investigation prior to the commencement of site works. The selection of Characteristic Values of geotechnical parameters (refer AS 5100), the modification of these values by using Geotechnical Strength reduction factors and the use of these modified values in calculating ultimate limit state design capacity must be fully understood. Communication between the bridge design engineer and the geotechnical engineer to achieve an appropriate understanding is imperative.

Where the geotechnical investigation is limited to the investigation of mobile riverbeds prior discussion with the MRWA Waterways Section is necessary. The objective of this type of investigation is to identify the approximate limits of clear water and live bed scours for the purposes of foundation design of bridges and floodways and invert levels of culverts. The types of geotechnical field investigation are usually site specific and require discussion with the structural and waterways engineers.

Defining the scope of the investigation (eg. number of test locations, type of test, frequency and depth) is not covered explicitly by these guidelines.

The number, location and depth of tests is to consider:

- expected sub-surface conditions
- previous geotechnical information available

- likely extent of zones in ground influenced by loading
- need to achieve a reliable geotechnical model for analysis
- size and importance of the structure
- requirement to minimise contractor and MRWA risk of changes during the construction programme due to variations in the subsurface conditions from that reported during the investigation stage.

Allowance should be made for the anticipated level of variability in ground conditions and possible changes to the design. An experienced geotechnical engineer must make these decisions and discussion on the number, location and depth of the selected tests must be a part of the geotechnical report. This discussion must enable the reader of the report to understand what factors were used to assess these variables and provide a clear understanding of the deliverables.

While the above points should be covered by a well planned investigation there may be situations where during the investigation stage it is considered by MRWA or the geotechnical consultant that additional investigation will be required to generate a more reliable model and minimise risk. This work shall be undertaken at a schedule of rates agreed upon prior to the commencement of the investigation.

The following references contain supplementary comments, which should be read and implemented into investigation and testing as relevant.

Australian Standard	AS1726	“Geotechnical Site Investigations”
Australian Standard	AS1170	“Structural Design Actions”
Australian Standard	AS2159	“Piling – Design and Installation”
Australian Standard	AS5100	“Bridge Design-Foundations and Soil supporting structures”

All in situ testing, for example Standard Penetration Test (SPT), Electric Friction-Cone Penetration Test (EFCPT) etc, should be carried out in accordance with the relevant Australian Standards and supervised accordingly. The purpose of in situ testing is to determine the soil parameters necessary for the design of foundations.

Groundwater must be investigated to determine:

- the level of the permanent water table at the time of the investigation
- occurrence of a perched water table condition and its level
- estimated rates of inflow to excavations
- effects of de-watering on water table levels and on adjacent structures
- the presence of sub-artesian conditions
- the potential aggressiveness of the soil and groundwater, for example SO₄, Cl, pH and Total Dissolved Solids (TDS) to buried concrete and steel.

For most cases it will be necessary to install standpipes in selected boreholes to enable sampling and observations of water to be made. An allowance in cost estimates must be given to these installations.

3.4 Laboratory Testing

In conducting laboratory testing, procedures to be applied shall be in accordance with Australian Standards, Main Roads Standards, or American Standards (ASTM) and other relevant registered procedures. Because most bridge investigations are based upon Australian Standards requirements, those shall be applied where possible. Laboratory testing shall only be carried out in NATA accredited laboratories for the particular tests in question. All test results shall be presented as NATA endorsed reports.

It is advisable to store all soil and rock samples for projects; at least until construction of the sub structure is completed. They are useful to prospective tenderers in assessment of site conditions. They are also valuable in the event of engineering problems or contractual disputes during construction and useful in establishing relationships between site investigation data and in situ conditions.

4. GEOTECHNICAL REPORTS

The information contained in a geotechnical report would normally be used for design, tendering and construction purposes. The report should be prepared in two parts:

Part 1 – (“*Site Investigations Report*”) details of all field and laboratory test data to be represented

Part 2 – (“*Interpretative Report*”) the geotechnical evaluation, interpretation, conclusions and recommendations

Each part should be complete in itself with Part 2 containing all the information presented in Part 1, Site Investigations Report. Both parts should contain keys to all symbols, terms and abbreviations used, together with a clear statement of any limitations which apply. A special preface sheet must be included with all information distributed to Tenderers or Contractors.

The Information for Tenderers Document shall contain all factual and interpretive data relevant to the construction of the works. Professional opinion shall generally be excluded. Where professional opinion is considered essential to minimising the Principal’s risk, it shall be clearly and appropriately qualified as opinion only.

Part 1 – *Presentation of Site Investigation*

The presentation of factual geotechnical information will include, but not be limited to, the following:

- Purpose and scope of the geotechnical investigation, including a discussion on the extent and scope of the investigation.
- Brief description of the project for which the geotechnical report is being compiled giving information about the location of the project, its size and geometry, anticipated loads, structural elements, materials of construction, etc., and also giving a statement of the anticipated geotechnical complexity and risk associated with the project.
- Dates between which field and laboratory work were performed.
- Detailed description of methods used for the field and the laboratory work with reference to accepted standards followed, and with discussion on rationale used to determine type, spacing, frequency and locations of all tests.
- Types of field equipment used.
- Presentation of field observations which were made by the supervising field personnel during the execution of the sub-surface explorations.

- Data on fluctuations of groundwater table with time in the boreholes during the performance of the fieldwork and in piezometers after completion of the fieldwork.
- Compilation of individual boring logs, penetrometer results etc. for each of the test locations with descriptions of sub-surface formations based on field descriptions and on the results of laboratory testing. In addition the location and level of each of the test locations shall be accurately defined by survey control.
- Colour photographs of rock core.
- Grouping and presentation of field and laboratory test results in appendices and as summary tables.
- Names of the persons responsible for geotechnical site investigations and report writing.

Part 2 – Presentation of Evaluations, Conclusions and Recommendations

(a) Evaluation of geotechnical information

The evaluation of geotechnical information will include, but not be limited to, the following:

- Review of the field and laboratory work by the Geotechnical Engineer. In cases where there are limited or partial data, the Geotechnical Engineer should state this. If in the Geotechnical Engineer's opinion, the data are defective, irrelevant, insufficient or inaccurate; he/she should point this out and qualify comments accordingly. Any particular adverse test results should be considered carefully in order to determine whether they are misleading or represent a real phenomenon that must be accounted for in the design.
- Tabulation and graphical presentation of the results of the field and laboratory work in relation to the requirements of the projects.
- Determination of the depth to the groundwater table and its seasonal fluctuations.
- Sub-surface profile(s) in graphic form (geotechnical profile or model), showing the disposition of the various sub-surface formations. Detailed description of all sub-surface formations in relation to their physical properties and their compressibility and strength characteristics. Comments on irregularities such as pockets, cavities etc.

- Collating and presentation of the geotechnical data for each sub-surface formation. This presentation should be in a form which would enable selection of characteristic values for design.
- Submission of proposal(s) for further field and laboratory work, if deemed necessary, with comments justifying the need for this extra work.

(b) *Conclusions and Recommendations*

The conclusions and recommendations of a geotechnical report will include, but not be limited to the following:

- Classification of the project according to geotechnical complexity.
- Selection of suitable characteristic values for the requirements of the project (geotechnical design parameters).
- Settlement and stability computations.
- Recommendations concerning problems that may be encountered during excavations, pumping operations, construction of retaining structures and ground anchors, placement of earth materials etc.
- Comment on likely interaction of work on nearby structures.
- Recommendations on any other issues e.g. for surface drainage if required.
- Comments on liquefaction potential, scour depth, unsuitable soil etc. if applicable.

REFERENCES

GOLDER ASSOCIATES PTY LTD	REPORT ON GUIDELINES FOR GEOTECHNICAL INVESTIGATIONS MRWA BRIDGE AND WATERWAY STRUCTURES, Report No 00640283.
STANDARDS AUSTRALIA	GEOTECHNICAL SITE INVESTIGATION, AS1726.
STANDARDS AUSTRALIA	STRUCTURAL DESIGN ACTIONS, AS1170
STANDARDS AUSTRALIA	PILING - DESIGN AND INSTALLATION, AS2159.
STANDARDS AUSTRALIA	BRIDGE DESIGN – PART 3: FOUNDATION AND SOIL SUPPORTING STRUCTURES, AS5100.3.

CLASSIFICATION :

SUBJECT AREA : Geotechnical engineering

KEYWORDS : Geotechnical, bridge, foundation, investigation

APPENDIX A

FLOW CHART ON GUIDELINES FOR GEOTECHNICAL INVESTIGATIONS FOR BRIDGE STRUCTURES

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