DEPARTMENT OF MINES
SOUTH AUSTRALIA

GEOLOGICAL SURVEY

SOILS GEOLOGY SECTION

REPORT ON SITE INVESTIGATION
DAMAGED E.T.S.A. SUB-STATION BUILDING
BERRI
HD. LOVEDAY

by

P. G. Miller
Geologist

Rept. Bk. 50/163
G.S. 1726
D.M. 342/60

28th April, 1960

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RB 50/163

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CONTENTS

PLANS

Plan No.		Scale
60-241	Plan showing wall damage, E.T.S.A. Sub-station, Berri, Hd. Loveday.	8 feet = 1 in.

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I SUMMARY

The soil on the site examined is a poorly consolidated dune sand, partly solonized. The sub-station building is extensively cracked, particularly in the south-west, and north-west corners. The damage has been caused initially by foundation settlement, and further aggravated by the shrinkage of the cement bricks. Foundation settlement was due mainly to poor drainage disposal, causing the area beneath the foundations to become saturated, with a resultant loss of strength of the subsoil. The loading on the foundation is such that there is little margin of safety even when the material is in the dry state, and possibly shear failure of the soil has also occurred, contributing to some of the foundation settlement. The eastern portion of the building is only slightly affected, mainly because the foundation are located at a greater depth, thus increasing the bearing capacity, and also partly because of the more rigid construction of the walls in this area.

To remedy the situation adequate drainage disposal and the sealing of the building surrounds will be necessary. Underpinning with a concrete pad at the north-west and south-west corners is also advisable to reduce the loading at these points, and prevent further settlement.

II INTRODUCTION

This investigation was carried out following a request by Mr. Bates, Property Officer, E.T.S.A. Foundation settlement at the switch house building has caused extensive cracking in the external walls, and information was required on subsurface foundation conditions, and the probable cause of the settlement.

The site is situated in Zante Road, Berri, adjacent to the Berri Railway Station Yards. The appropriate map reference is Hundred of Loveday.

III SOIL PROFILES

The site is situated on the northern slope of a fixed sand dune. The switch house building is located on an excavated bench, the southern walls of the excavation being approximately six feet high, decreasing in a northerly direction until the surface of the bench intersects the original ground surface. Consequently the building is seated approximately six feet below the surface at the southern end, and on the original surface at the northern end.

Two test holes were put down at the site using a 2 feet diameter earth auger operated by the Trust. The following soil profile was obtained from the hole at the south-west corner of the building.

0'0" - 2'0"	Reddish-brown to orange, vaguely mottled, fine to medium-grained sand. Moderately compact.
2'0" - 3'3"	Reddish-brown and pale reddish-brown compact sand, the lighter patches probably being limey.
3'3" - 11'	Reddish-brown fine-grained sand with lighter coloured limey patches and some incipient nodules. Soft and damp.

The soil profile at the north-west corner of the building is essentially similar except that the upper portion of the profile is more limey, being on the original natural surface.

This profile is typical of aeolian dune material as evidenced by the poor profile development and the fine, even-grain-size of the sand. Slight solonization has occurred, but the lime horizon is not well developed.

This dune material is very common in this area, and although in normal seasons the dunes do not migrate, in prolonged drought periods severe erosional effects can be noticed, and the dunes may migrate under the influence of the wind.

IV PHYSICAL CHARACTERISTICS

This soil type, being composed essentially of fine sand, is not expansive, ie. not subject to seasonal shrinking and swelling movements. However because of the aeolian mode of deposition, the consolidation of the sand is poor. Consequently the strength of the material is low, the soil being prone to shear failure under relatively low loadings.

The sand is also very sensitive to wetting, with a resultant loss of strength. This is partly due to the tendency of the sand grains to settle when the soil is completely saturated, and partly to a physical characteristic of the limey material within the profile. The limey material becomes very soft and unstable with increase in moisture content, and may collapse completely when fully saturated. As a result should any portion of the foundation area of a building become unduly saturated differential settlement of the building is almost certain to occur.

Consequently these dune sands do not provide good foundation conditions. The strength of the material in the dry state is low, and is further decreased should saturation occur. It is essential therefore to provide adequate and complete drainage on these soils to maintain as near as possible, constant moisture conditions in the foundation area.

V STRUCTURAL DAMAGE AND PROBABLE CAUSE

The building, which is constructed of cement brick, is severely cracked particularly in the western portion. The extent of the damage can be seen on the attached plan, where the major cracks have been recorded. The cracking has obviously been caused by foundation settlement, particularly at the corners of the building, the windows and doors of the building providing places of weakness where the walls have failed. No foundation damage could be detected, but such cracks are generally of very small dimensions making detection difficult, and it is also possible that the foundation used for the building could sustain sufficient deflection to suffer the

settlement without failure.

From an analysis of the cracking in the walls it would appear that the north-west and south-west corners of the building have settled quite considerably, the stresses so imposed being relieved by severe tension cracks through the windows and doors. The eastern portion of the building does not show such severe movement, although tension cracks are still present to a lesser degree. This is due to the type of construction used in these walls, viz reinforced concrete internal walls, and also to the fact that the foundation for this portion of the building is located approximately 2 feet deeper in the soil profile, thus considerably increasing the bearing capacity of the soil.

From the soil profile it is considered that the maximum loading that should be used for foundations located 1 foot below the surface is ½ ton per square foot, provided saturation does not occur. The loading of the building is approximately ½ ton per square foot, and therefore the soil should have just sufficient strength to support the loadings, and shear failure should not have occurred. However as previously mentioned, any saturation of the dune material results in a decrease in strength. The drainage at present provided for the disposal of roof water from the building is obviously inadequate, and flooding of the area immediately adjacent to the foundations is common, particularly at the south-west and north-west corners. The north-east and south-east corners would also be affected to some extent, but a slight slope of the surface would cause the surplus water to be drained away from the building Consequently it may be assumed that after heavy rains the foundation areas are saturated, causing a loss of strength in the soil within the foundation area.

Although the original failures have been caused by foundation settlement, the severity of the wall cracking has probably been accentuated by the type of material used in the construction. Cement bricks, even when well constructed, are subject to quite significant shrinkage, and it is probable that the original cracking due to settlement has been considerably

worsened by the internal shrinkage of the walls.

VI CORRECTIVE MEASURES

The extensive cracking present in the walls of the switch-house is attributed mainly to settlement of the north-west and south-west corners of the building. Remedial action is obviously necessary to prevent a worsening of the present structural damage, and further settlement must be prevented before the wall damage is repaired. To prevent further settlement corrective measures must be adopted, and the method to be used will depend upon the following factors.

1. Whether settlement has been due solely to shear failure of the soil, or solely to settlement due to saturation, or to a combination of both. In the opinion of the writer, for foundations such as were used in the western portion of the building, the soil should support a maximum loading of ½ton per square foot, provided undue saturation of the soil is prevented. The loadings used on the surface are of this order, indicating that there is very little margin of safety. Consequently it is difficult to assess whether shear failure due to the loading has taken place, particularly as the loading value is an estimated value only. However it is thought that the effect of shear failure would be slight, and that the main cause of the settlement has been the loss of strength incurred by the soil due to saturation.

2. Whether the soil beneath the foundation has reached a state of equilibrium, and because of the settlement the strength has been sufficiently increased to support the loading. From local reports the cracks in the building do not appear to have increased in the last three years. This may indicate that the initial foundation settlement has caused a consolidation of the sand beneath the foundations, thereby increasing the strength of the soil. Consequently further settlement is unlikely if drainage precautions are adopted to prevent further saturation of the foundation area.

From the above two factors two alternative approaches

can be used in effecting repairs of the building.

The first is to assume that further settlement will not occur, provided drainage precautions are observed. The drainage precautions should consist of ensuring that constant moisture conditions are maintained in the foundation area. All roof water should be carried well away from the foundations in properly constructed drains of adequate capacity. Surface drainage, particularly from the walls of the excavation should be diverted away from the building. A concrete or some other impervious pavement surrounding the building would assist in this respect, and is virtually essential on this type of soil. The pavement should be at least 6 feet wide, preferably wider, and if concrete is to be used the pavement should be bonded to the foundation with a bitumastic compound to permit some differential movement and still maintain a waterproof seal.

The second approach would be to under pin the north-west and south-west corners with a reinforced concrete pad. No strong horizon, suitable for underpinning is present down to a depth of at least 12 feet, so that underpinning will be confined to reducing the load on the soil beneath the existing foundations. The pad would be easily placed into position in the south-west corner, and in this corner the foundation could be jacked up to reduce the foundation drop which has occurred. However the north-west corner of the building apparently presents some construction difficulties in this respect, particularly as the settlement is not confined solely to the corner. Consequently it may not be possible to jack up this corner, and underpinning would be confined to the placing of a concrete slab beneath the existing foundations. Following the underpinning drainage precautions as previously stated should be adopted.

Underpinning of the eastern walls is not considered necessary provided the drainage precautions are adopted.

VII CONCLUSIONS AND RECOMMENDATIONS

From the soil profile it is considered that the major cause of the settlement has been the failure to provide adequate drainage for the disposal of surplus water. However the loadings on the soil are near the maximum estimated for such a soil, and possibly some settlement due to shear failure has occurred. The soil beneath the foundations has probably reached a state of equilibrium due to compaction because of the settlement, and further settlement is unlikely provided constant moisture conditions are maintained in the foundation area by the adoption of special drainage precautions.

The low margin of safety for the existing foundation due to the loading being the maximum permissible, suggests that it would be advisable to place additional pads at the north-west and south-west corners to decrease the loading at these points.

Repairs to the walls should not be carried out until at least three months after the underpinning and drainage precautions have been completed. This is to enable the soil beneath the foundations to reach a state of moisture equilibrium, and any settlement that may accompany the change in moisture content to occur. If the cracks are repaired before the equilibrium is reached the slight settlement may cause them to reopen.

In future buildings of this type built on similar soils it would be advisable to use foundations of increased width preferably 30" wide for external walls, so that a greater margin of safety is provided.

Pre-consolidation of the area by flooding would also be beneficial where practicable.

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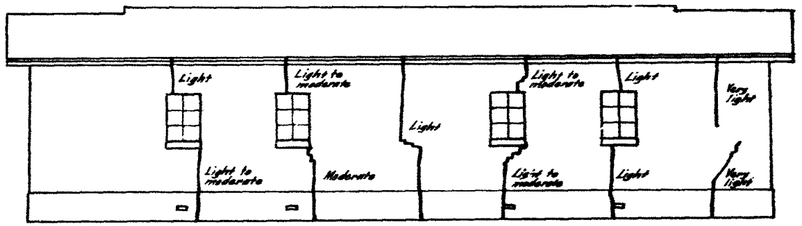
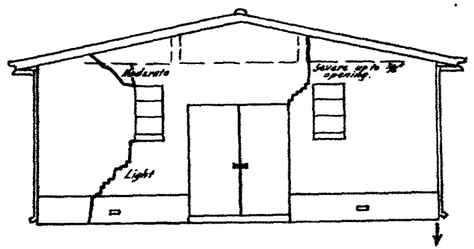
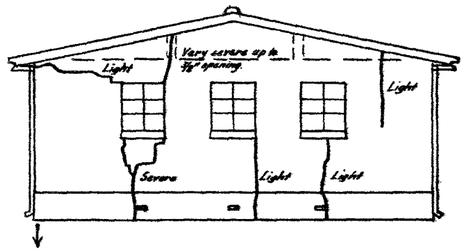
PGM:CERF
28/4/60



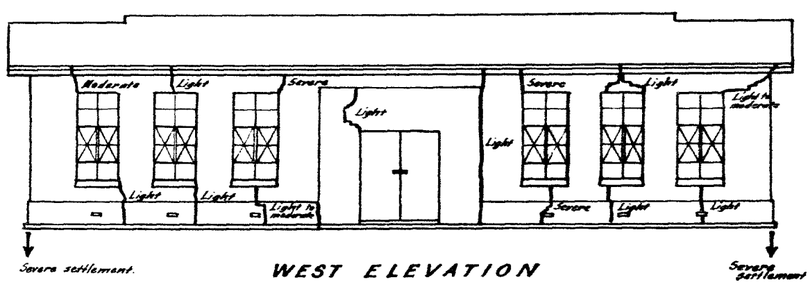
EAST ELEVATION



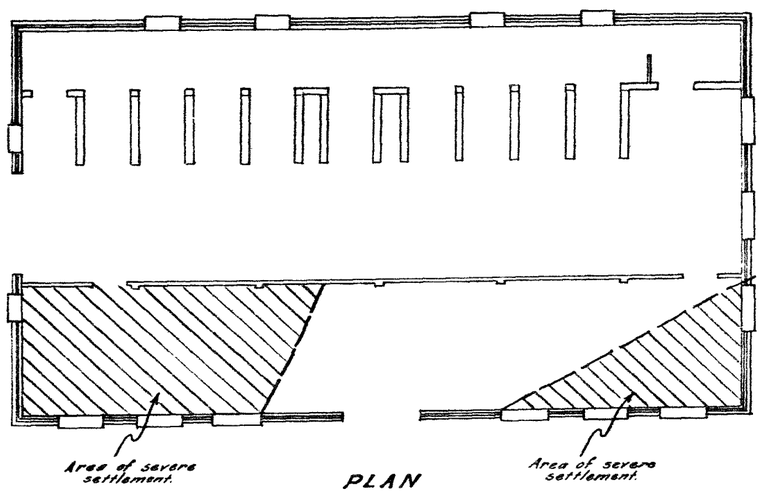
NORTH ELEVATION



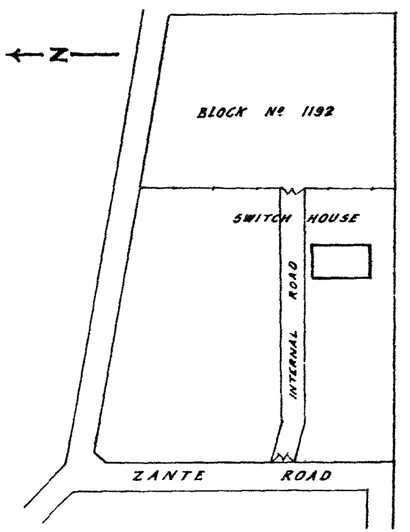
SOUTH ELEVATION



WEST ELEVATION



PLAN



SITE PLAN

To accompany report by P.G. Miller. 100 Feet to 1 inch

S.A. DEPT. OF MINES

100—7.58 1917

PLAN SHOWING WALL DAMAGE
E.T.S.A. SUB-STATION, BERRI
Hº LOVEDAY

Associated Drawing	No.	No.	Amendment	Exd.	Date

Req. No.
D.M.
Compiled from

Approved	Passed		Scale: 8 Feet to 1 inch.
		Drn.	60 - 241
		Tcd. R.R.	Gg 1
Director of Mines		Ckd.	
		Exd.	Date 27 - 4 - 60