Earthworks for Barry Curtis Park and Flat Bush Town Centre

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ABSTRACT

Earthworks are nearing completion for New Zealand's largest and comprehensively planned new town, covering 1700ha for an anticipated population of 40,000 people by 2020. Ground investigations have shown the site is underlain by alluvium ranging in thickness from 2m to 29m. Consolidation settlement and bearing capacity were identified as significant geotechnical constraints to site development at an early stage of the investigations. Earthworks have been carried out over a 3 year period. Settlements resulting from fill placement have been monitored and match closely those predicted. The alluvium will continue to be a significant constraint to the design of the foundations for town centre structures.

1 INTRODUCTION

New Zealand's largest and comprehensively planned new town will be located at Flat Bush covering 1700ha for an anticipated population of 40,000 people by 2020. Flat Bush is located close to Manukau City, which is New Zealand's third largest city, and the fastest growing city in the country. The development is one of the last major "green field" developments in the metropolitan district of Auckland. The project is being masterminded by Manukau City Council who aim to create a unique urban environment with a strong emphasis on parks and public places.

Figure 1: The proposed Flat Bush Town Centre and Barry Curtis Park

The hub of the new town will be the 18 ha Flat Bush Town Centre connected to existing roading infrastructure by a new landmark bridge to be known as Ormiston Road Bridge. The town centre will comprise a mix of retail, commercial and community facilities. The Town Centre is expected to have a completed value well in excess of NZ$ 500 million. The town's 40,000 residents will be accommodated in 15,000 new homes in and around the town centre and served by up to 7 new schools together with recreational facilities including an aquatic centre, multi-sports centre and library.

The new town will be surrounded by a park covering 94 ha and named after the Manukau Mayor, Sir Barry Curtis. The park will incorporate walkways, lakes, playing fields, an education centre and an open air concert venue.

One suggestion for the name “Flat Bush” is that it describes the appearance of the former forest on the site when viewed from the hills above. The trees were apparently all of a similar type and height and so formed a level canopy of bush (forest).

2 GEOLOGY

Flat Bush is located to the east of the volcanic cones of Auckland City. The IGNS geological map (Kermode 1992) records bedrock of the East Coast Bays Formation (15 to 24 million years old) overlain by Tauranga Group sediments (up to 2 million years old).

The sediments comprise pumiceous alluvial deposits deposited predominantly in river and lake environments. Former swamps have led to layers of peat and organic rich clays within the alluvium.

3 GROUND INVESTIGATION

A ground investigation was commissioned by Manukau City Council in 2003 and 2004. The purpose of the ground investigation was to provide geotechnical parameters for the design of the earthworks.

The investigation comprised:
20 machine boreholes to bedrock
68 cone penetration tests
105 hand augers
41 Scala penetration tests

Laboratory testing included moisture content, Atterberg Limit, particle size distribution, bulk density, one dimensional consolidation, triaxial, compaction and CBR tests.

4 GROUND MODEL

The investigations show the depth to bedrock is extremely variable, ranging from 2m to 29m. The variability reflects the presence of former valleys eroded into the rock before deposition of the overlying sediments. A former river valley is now buried below the proposed site of the town centre and the Ormiston Road Bridge, while much of the proposed parkland and ponds lie above former high ground with relatively shallow depths to bedrock. A simplified geological section across the town centre site is enclosed in Figure 2.

Tauranga Group alluvium overlies bedrock. Within the former valley, a 7m thick layer of black organic clay overlies a layer of stiff alluvium. A more recent layer of soft to firm alluvium covers the whole site topped by volcanic ash. A stiff crust 2 to 3m thick has formed across the site. Recent stream alluvium is also located within incised surface gullies.

An interesting feature of the upper alluvium layer is the presence of buried Kauri trees. Kauri is a New Zealand pine tree with an ancestry of over 100 million years. The tallest standing Kauri tree is over 50m high and 1500 years old. Many Kauri trees lie perfectly preserved in alluvial soils throughout the North of New Zealand. Some have been carbon dated at 50,000 years old.

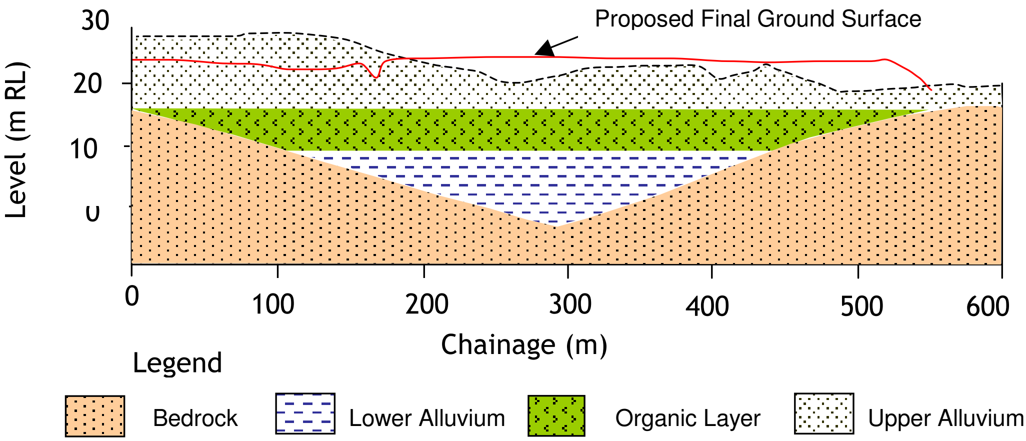

Figure 2: Geological cross section through the site of the proposed town centre

5 EARTHWORKS DESIGN

The design for the new town required extensive earthworks to be carried out to create a level platform for the town centre above the expected flood levels and to create the playing fields, ponds and parkland surrounding the town centre.

Cuts up to 4m deep would be required on the southern side of the town centre site with fill of a similar thickness necessary on the northern half. Approach embankments for Ormiston Road Bridge would reach 8m in height.

5.1 Settlement

Given the soft and organic nature of the alluvium, settlement was identified as a significant geotechnical constraint to development at an early stage in the investigation.

5.1.1 Primary Consolidation

Test results for the Coefficient of Volume Compressibility (m_v) are summarised in Figure 3. The results are perhaps somewhat counter-intuitive. Samples from the layer of black organic layer have a similar compressibility to the stiff lower alluvium while the upper, generally non-organic, alluvium shows the most potential for settlement.

The application of the test findings to predict the amount of primary consolidation settlement across the site was a complex problem. Significant variations in bedrock depth, cut and fill heights and the composition of the alluvium, meant no one settlement ground model could be applied to the site as a whole. Since laboratory test results were only available from a limited number of machine boreholes, a correlation between compressibility and cone resistance was necessary to increase the number of points at which settlement could be estimated.

A plot of the Coefficient of Volume Compressibility against cone resistance is shown in Figure 3. A design line was chosen to provide a simple correlation between the two sets of values. Based on this correlation, individual settlement estimates were performed at 76 locations across the site. The maximum settlement calculated was 160mm below the western bridge approach embankment.

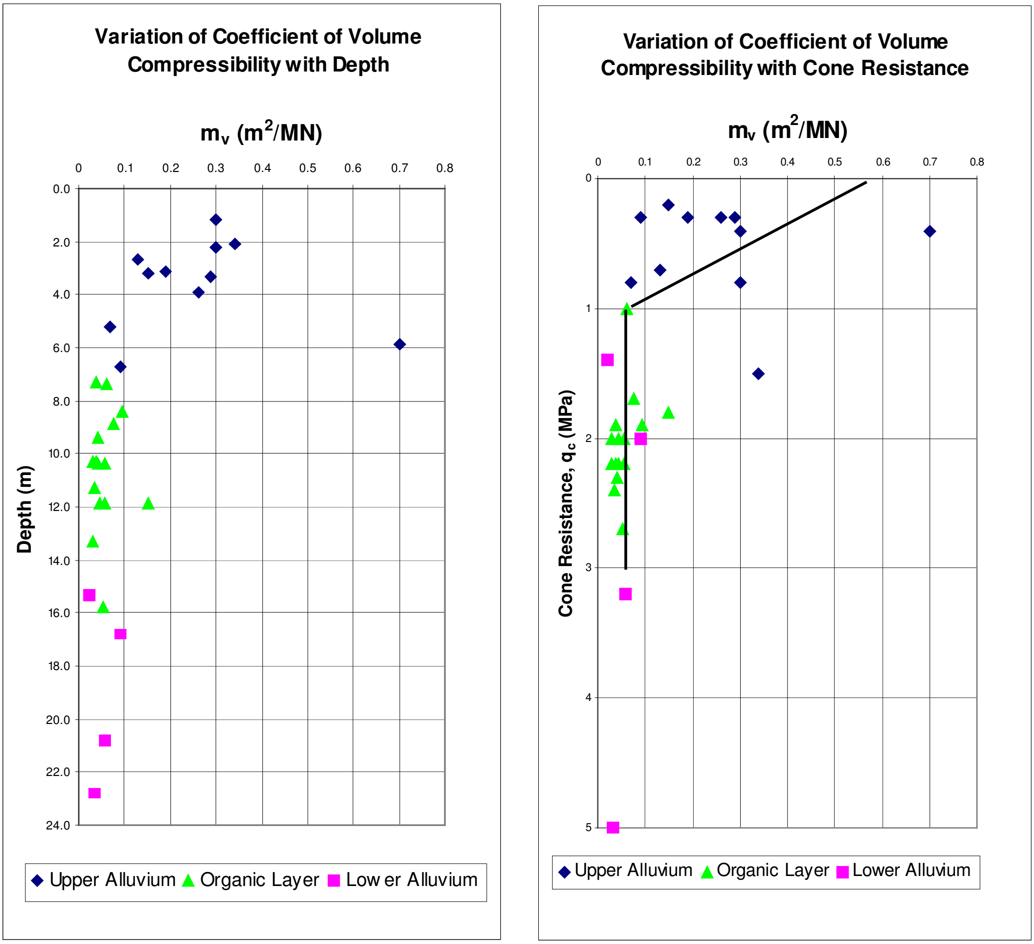

Figure 3: Variation of Coefficient of Volume Compressibility with depth and cone resistance

5.1.2 Time for Consolidation

The time for primary consolidation settlement to occur was estimated based on test results from consolidation, cone dissipation and field permeability testing. Laboratory test results for the Coefficient of Vertical Consolidation (Cv) were typically within the range 1 to 18m^2/year with some test results in the upper alluvium of up to 70m^2/year. Time for settlement to be 90% complete was estimated to be up to 12 months.

5.2 Bearing Capacity

It is common within the Tauranga Group soils for a stiff surface crust to form above the groundwater table. This has allowed the development of roads and timber framed housing without need for significant foundation improvement. But the earthworks for Flat Bush have required cuts up to 4m deep, which have removed the crust and exposed the saturated weaker alluvium below.

This softer alluvium could be treated to improve bearing capacity, but for larger buildings, settlement would then become the controlling factor for foundation design and, in most cases, require piled foundations in any case. The earthworks design therefore allowed for improvement of the running surface for plant movement but not for construction.

6 CONSTRUCTION

6.1 Earthworks

Earthworks have taken place during the 2004/5, 2005/6 and 2006/7 earthworks seasons.

Contractors carrying out earthworks for new subdivisions in New Zealand are experienced in 'mucking out' recent organic soils from gullies prior to fill placement. However some calibration was necessary at this site to enable the contractor to distinguish between the very recent and localised stream alluvium, which was to be removed, and the older Tauranga Group alluvium, which was to stay.

The other aspect, which made the earthworks unusual, was the treatment of the areas of deeper cut. The earthworks had been designed to leave the soft alluvium exposed in deeper cuts without treatment apart from a covering of 'brown' (weathered) rock fragments to provide a trafficable surface. However the 300mm of brown rock specified gave insufficient protection in some softer areas to prevent pumping beneath earthmoving plant and it was necessary to place a geofabric below the brown rock to prevent the soft alluvium being forced through the rock to the surface.

6.2 Instrumentation

Monitoring the rate and amount of consolidation settlement resulting from fill placement was essential to check settlement predictions. A preload period of 12 months had been incorporated into the construction programme, but if settlement proceeded at a slower pace or the amount of settlement exceeded settlement predictions, action would need to be taken after the first 6 months to accelerate consolidation or extend the preload period.

Given the multi-layered ground profile, monitoring settlement at the ground surface could mask the behaviour of individual layers and so borehole extensometers were chosen. Eight extensometers were installed in areas of proposed fill.

Installation and maintenance of the extensometers were not without its problems, which were compounded by unfamiliarity in New Zealand with this type of instrumentation and the supply of flexible large-scale movement extensometers rather than the stiffer rigid tube extensometers, which would have been better suited to the site. However reasonable results were eventually obtained from most instruments.

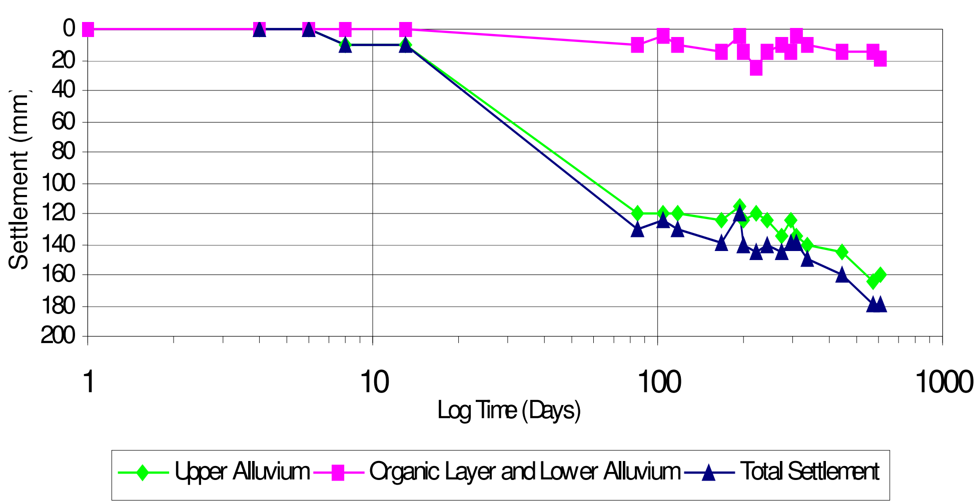

Figure 4: Settlement at the extensometer at the western bridge approach embankment

Figure 4 shows readings from the extensometer matching the location of the maximum predicted settlement below the 8m high western bridge approach embankment and results show close agreement with the predicted amount of settlement.

Settlement within the organic layer and lower alluvium is very small in comparison to that in the upper alluvium as indicated from the laboratory test results.

Settlement was largely complete after the first 3 months, well ahead of predictions, but additional filling then took place, which has resulted in additional settlement after the 12 month preload period.

7 IMPLICATIONS FOR TOWN CENTRE STRUCTURES

The implication of the ground conditions on the proposed town centre structures is significant. Structures up to 8 storeys high are proposed and deep piled foundations will be necessary to support the majority of these buildings.

The low strength alluvial soils within cut areas will also limit foundation options for buildings of a lower height.

By contrast, foundations for the park amenity buildings will be relatively straightforward, where bedrock is closer to the surface.

8 CONCLUSIONS

Flat Bush is New Zealand's largest and comprehensively planned new town covering 1700ha for an anticipated population of 40,000 people by 2020.

The site is underlain by East Coast Bays Formation bedrock and pumiceous alluvium of the Tauranga Group.

The depth to bedrock is highly variable reflecting the presence of former valleys eroded into the rock before deposition of the alluvium. The town centre and a major bridge are located over one of the former valleys.

Ground investigations and laboratory testing have been carried out for the design of the earthworks.

Consolidation settlement of the upper alluvium and bearing capacity are the most significant geotechnical constraints.

Settlement was monitored during construction and matched closely the amount of predicted settlement but occurred within a shorter time frame.

The implications of the ground conditions on foundations for the proposed town centre structures will be significant with deep piling required for the majority of structures. By contrast, foundations for buildings within the surrounding parkland, where bedrock is closer to the ground surface, will be relatively straightforward.

REFERENCES

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