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Innovative Technologies for Severe Weather and Climate Change

Edited by
Sherif El-Badawy, Ph.D.
DingXin Cheng, Ph.D., P.E.
Mohamed Arab, Ph.D.

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Preface

This Geotechnical Special Publication (GSP) contains 20 papers that were accepted and presented at the GeoChina 2016 International Conference on Sustainable Civil Infrastructures: Innovative Technologies for Severe Weathers and Climate Changes. The conference was held in in Shandong, China in July 25-27, 2016. The conference provided a showcase for recent developments and advancements in design, construction, and safety inspections of transportation infrastructures and offered a forum to discuss and debate future directions for the 21st century.

The presented research papers cover many interesting and contemporary topics including foundation failure and repair, rehabilitation strategy selection and preventative maintenance treatments, asphalt binder and mixture characterization, design methods and materials, innovative repair methods and materials, durable and sustainable designs, innovative materials, advances in foundation design/construction, accelerated and/or performance based design/construction, and aesthetics and environment. The overall theme of the GSP is the development and application of innovative technologies for severe weathers and climate changes and the presented papers address different research findings of this theme. It provides an effective means of disseminating recent developments, advancements, innovative technologies, and research results concerning sustainable civil infrastructures among scientists, researchers and engineering practitioners.

We would like to thank all the participants for their contributions to the success of the conference program and their contributions to this Geotechnical Special Publication (GPS).

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Straightening Two Tilted Buildings Using Two Different Techniques

Carlos E. M. Maffei, Ph.D.[1]; and Heloisa H. S. Gonçalves, Ph.D.[2]

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Abstract: This paper aims to describe two different techniques used to straight reinforced concrete buildings complex in Santos, Brazil, which is composed by two towers. At the end of the year 1998, before the recovery works, Tower A was 2,08m out of the vertical position while Tower B was almost the same. Towers A and B are 57m high. First, a safety assessment analysis was undertaken through a modern computational program. The analysis has shown that the strengthening of the structure of the Tower A was urgent, since the building could be in risk of structural collapse after ten years. The Tower B wasn´t in near risk because Tower B is largest than Tower A. The inclination of these buildings was corrected using different techniques presented in this paper.

INTRODUCTION

The city of Santos, located 68km far from the capital of the State of São Paulo, is the largest and the most important city of Baixada Santista, where the largest harbor in South America is installed. The construction of tall buildings, in the city of Santos, started in the 40`s, generated one of the most serious social problems for the community. Along the coast there are about a hundred buildings visibly inclined, due to differential settlements occurred to the thick layer of soft clay existing below the layer of compact sand, which the buildings foundation lean on.

The towers of "Condomínio Núncio Malzoni" were built in 1967 on shallow foundations at 2m depth interlocked by rigid beams with transversal sections dimensions 30cm X 150cm. In the same construction period of towers, similar buildings, with similar foundations were erected on its left side. The geotechnical profile representing this area is shown in Fig 1. The superposition of the pressure bulbs on the deep soft clay layers caused additional settlements making the buildings tilt, as it can be seen on Fig. 5.

The differential settlement are responsible for the inclination of more than 2,2^{o} observed at the frontal view and 0,6^{o} at the lateral view of the Tower A and 1,8^{o} observed at the frontal view and 0,4^{o} at the lateral view of the Tower B (Fig. 8 and 9).

Despite of the inclination of the structures, buildings have not presented any cracking as the buildings have moved as rigid body, due to rigidity of foudations. In the last 20 years, the settlement speed of both buildings varied between 0,5cm and 1,5cm a year, constant in each pillar.

A careful study was accomplished in these towers, in order to assess the real conditions of structural stability (Maffei, 2001). A computer program, named "PORCA" was used in this verification (Pimenta, 1998). Program allow non-linear behavior of reinforced concrete, geometrical non-linearity and generation of plastic hinges.

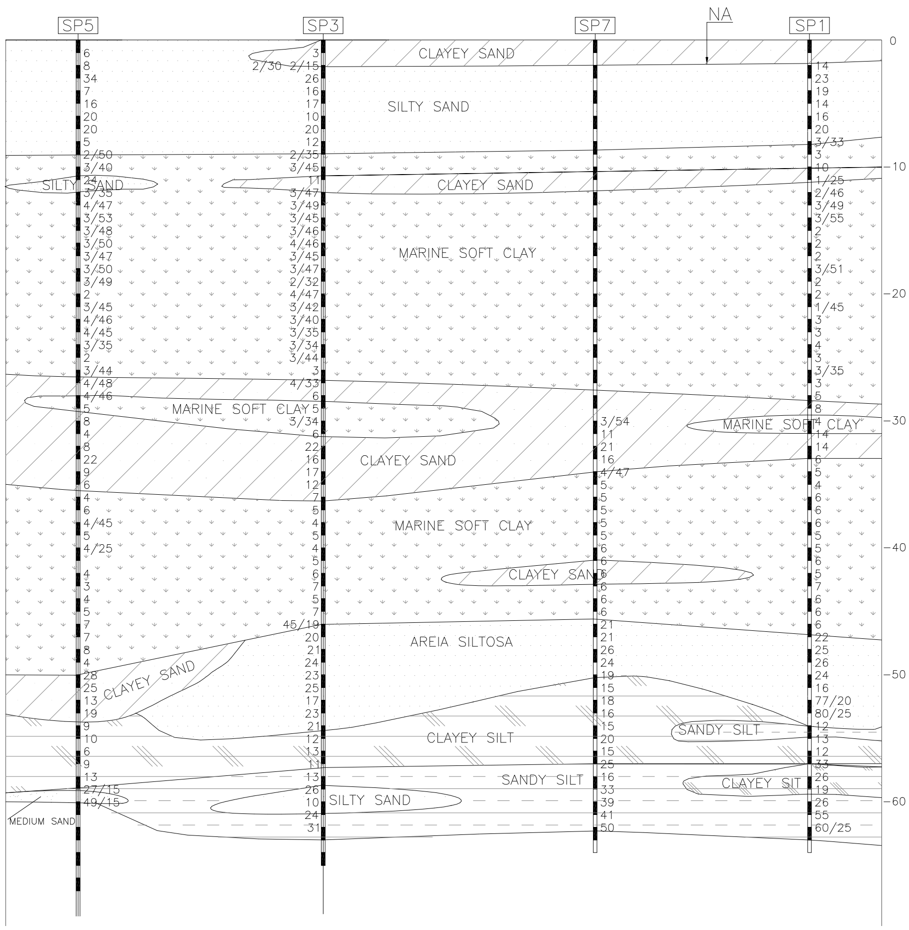

FIG 1 . Subsoil profile of the Núncio Malzoni Condominium site

TECHNICS APPLIED TO CORRECT BULDING INCLINATIONS

The plant of the Tower A and the Tower B is in figure 2.

Tower A

The reinforcement design (Fig. 3) to correct the tilted of building "A" can be divided into three stages :

- Implantation of 16 bored piles with variable diameters ranging from 1m to 1,4m and 55m long
- Construction of transition beams, seven of the main beams used to be transversal beams of the “Virandeel” kind, the others used to transfer the load of pillars that were not aligned to the main beams
- Laying of fourteen hydraulic jacks among the piles blocks and the seven “Virandeel” beams . The hydraulic jacks had a capacity ranging from 400 to 900 tons.

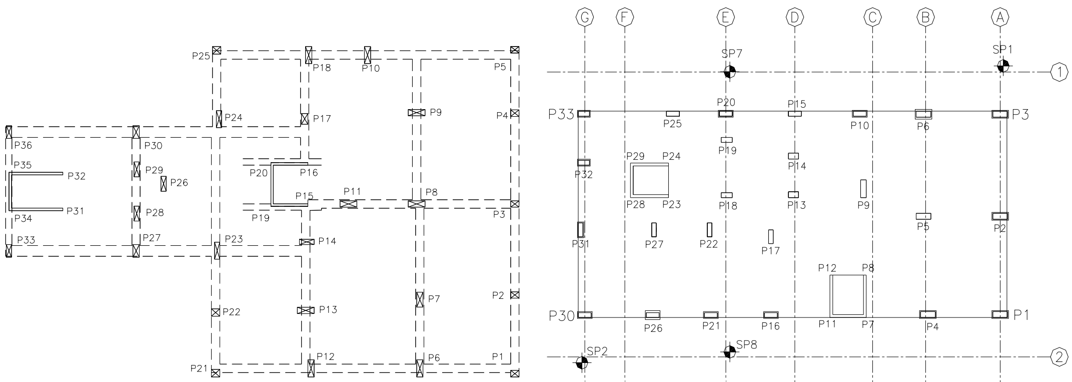

Fig 2. Plant of the Nuncio Malzoni Condominium

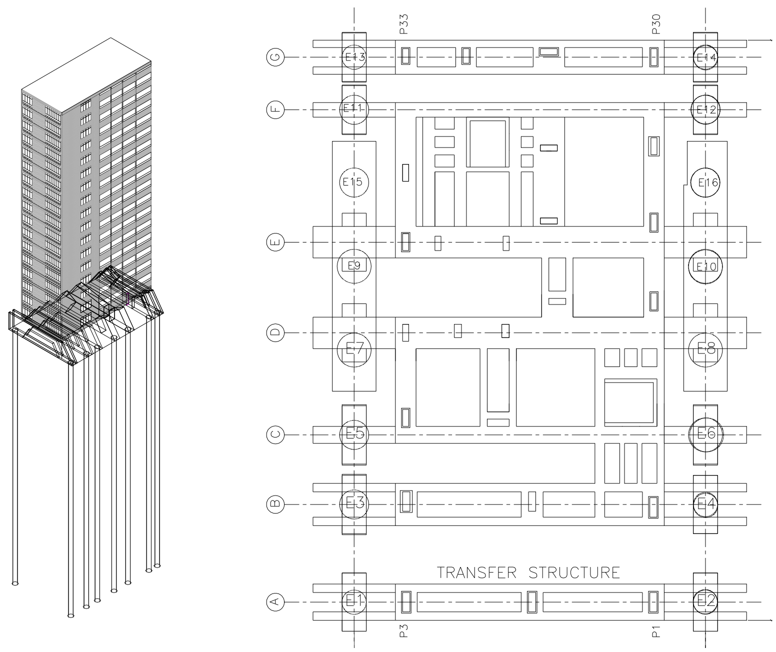

FIG 3. Reinforcement design

The building, which was showing a slant of 2,10m, was put back into plumb. The more settled pilar was raised 80cm. During at the reinforcement execution stages, settlements were measured. The execution of piles, blocks and transition beams followed a previously study sequence so as not to accelerate the differential settlement during operations.

During the correction operation, the settlement pins were transferred temporarily for the beams involving the pillars, some deflectometers were installed between hydraulic jacks and transition beams and additional pins at the piles blocks. With all this information, each step of jacking was controlled. Despite many piles had received more load than predicted at the time of the survey of the building, the maximum settlement of the piles was 0,6cm.

The figure 4 shows the hydraulic jack system before and after the correction of inclination of building and it is possible to see the wedges placed at each lifting operation of the building. Figure 5 shows the building before and after the conclusion of re-straightening operations.

FIG 4 Jack system before and after the straightening

FIG 5. Photos before and after the re-leveling

Tower B

Structural analysis and executive design of the Tower B were made soon after Tower A. However, as the geometrical characteristics of the two buildings were very different, the structure model to re-leveling the Tower B had to be different, because there was no enough space for the large-diameter excavated piles installation on the sides of the building and neither for the construction of the "Virandell" beams, like in the Tower A.