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Remedial Works to Arrest the Differential Settlement of SABIC Building Foundations

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ABSTRACT

This paper discusses the remedial actions taken to address the ongoing settlement issues in the raft foundation of the East Wing of the SABIC Building in Al-Jubail, Saudi Arabia. The expansion joint between the East Wing and the main building exhibited continuous movement, reaching an opening of 150 mm at the top of the roof level. The study explores potential causes such as ground spreading, differential settlement, and seasonal thermal expansion. Remedial measures involved the installation of a Micropiling support system comprising 103 micropiles to stabilize the East Wing framing system and mitigate soil pressure under the raft. The work includes also the instrumentation of the structure for long term monitoring.

1. INTRODUCTION:

Structures, by their nature, undergo gradual settlement over time due to loading and soil movement. However, when settlement becomes excessive or irregular, it can pose many concerning challenges to the structural integrity of buildings. The SABIC Building in Al-Jubail represents a multi-story reinforced concrete structure supported by a continuous raft foundation. The persistent and noticeable movement of the expansion joint between the East Wing and the main building raised concerns, thereby requiring an exhaustive study to proactively address the issue before it escalates into a more severe problem.

2. PROBLEM STATEMENT:

The movement observed in the expansion joint indicated soil pressures exceeding recommended levels, thereby calling for the urgent need for remedial measures. A list of potential causes, ranging from thermal and moisture movements to geological factors and lack of lateral restraint, were carefully examined and analyzed. Through sophisticated monitoring mechanisms, the underlying causes behind the observed movements were identified, with localized differential settlement and seasonal expansion emerging as significant contributors to the overall settlement dynamics.

3. DESIGN AND DETAILS OF FOUNDATION SUPPORT:

The following remedial measure was designed and executed to prevent further settlement and tilting of raft foundation of SABIC Building's East wing.

Structural analysis and design software was used to construct a 3-D model of the structure and the raft foundation was modelled as a Slab-on-Elastic Springs. In addition, the piles were modeled as multi-linear phase springs, in which the nonlinear phase of the pile was introduced to the system based on the information gathered from the pile's load test. The effect of stone columns in the soil was ignored and considered completely deteriorated.

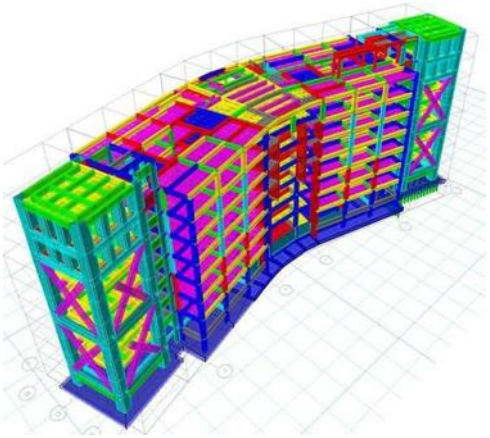
A major variable in the system was the coefficient of subgrade reaction of the virgin soil under the raft [K-value in kN/m3]. The adopted K-value for the soil in its current conditions was derived by an iterative numerical analysis of the structure, so that the tilting in the analysis model matches the reported tilt in the East Wing.

4. MICROPILE FOUNDATION SUPPORT:

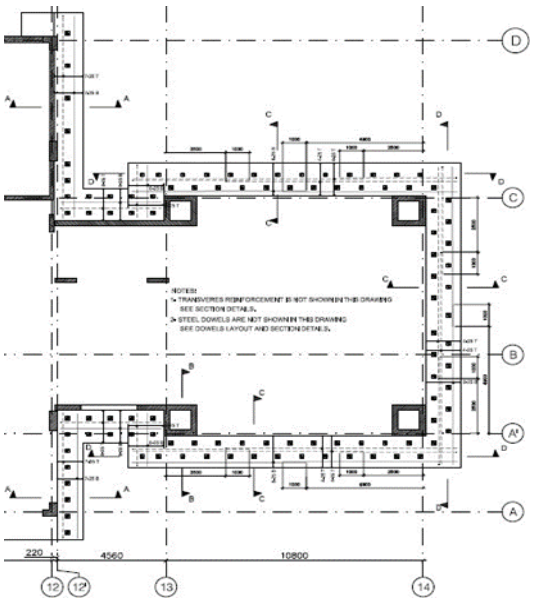
A Micropiling system consisting of 103 piles, with steel hollow rod 53/29, 175 mm drill hole, 225 mm grout body, 25.5 m long under the soffit of the raft was found to be adequate to stabilize the East Wing framing system and limit the applied soil pressure under the raft to the recommended allowable soil capacity of 100 kPa. Utilizing three- dimensional Nonlinear analysis of the Micropiling system, it was concluded that the East Wing is feasible to be stabilized from outside and avoid service disruption of the building interior.

The maximum geotechnical load capacity of the pile was found from the pile load test to be 700 kN, considering a resistance factor of 0.7 as per AASHTO Table 10.5.5.2.5-1. The pile's structural capacity was checked for the maximum recorded axial load during the pile load test, which was 104 tons (1020 kN). This assumption was made to cover any loading conditions where the load in the pile could reach the maximum tested load of 1020 KN. The pile cap was designed and checked for punching, shear, bond and bending forces.

All piles were under compression with no tension in any of the considered load combinations. The existing reinforcement in the raft was found to satisfy the strength requirements for loading conditions. The thickness of the raft was also found to be adequate to resist the applied forces.



3-D model of the building structure



Micropiling layout for East Wing Raft Foundation

5. CONCLUSION:

The paper concludes by emphasizing the successful implementation of remedial measures to address differential settlement in the SABIC Building foundations. The Micropiling support system proved effective in stabilizing the East Wing, highlighting the importance of proactive structural interventions in mitigating settlement issues.