Modeling, Analysis and Design of Mat on Pile Foundations

Using 2D Plate/Shell Finite Element Based Models


Buddhi S.


Suda T.

Main Issue Addressed in This Article

Can we rely on 2D (Planar) FE model (such as adopted by CSI SAFE software) for finding the design reactions on piles and design actions (M, V) and deflections of Mat on pile?

Why This Article?

In last 5-6 years we have encountered this question many times, practically, every case that we were involved in the design of building projects that include pile-mat foundation and the questions revolved around the one shown on the first paragraph (above).

Short Answer

Based on our knowledge of Finite Element Analysis and design experience we have found:

(1) 2D Planar FE model for Pile-Mat can't capture the true short and long-term distribution of superstructure load on pile through mat, though such analysis apparently maintains the overall equilibrium of the system. One very common case to justify this point is that, with 3-5 m thick mat on large bored piles (1-1.5m dia) @ 5-6m center to center, one easily gets reactions (as analysis output) on four adjacent piles in the order of 4,000; 2,000, 1,000 and 500 ton.

(2) As the vertical reactions on piles are not correct, same will be the case with the moment and shear forces produced on the mat (modeled as plate/shell). We can easily understand this point just by comparing the one strip of mat as multi-span beam using the simple logic that Moments & Shears can't be correct unless Reactions are correct (Equilibrium Law).

Short Explanations

(1) Quick review of the fundamental formulation of Finite Elements, the plate/shell in this case, one can easily identify that these elements are not developed or meant to model thick/deep structures like Transfer Girder, Pile-Caps, Mat Foundations and so.

(2) By definition the plate/shell elements are suitable to model that situation where the in-plane dimensions are significantly larger (say in the order of 4 or above) than the vertical dimension. In current case, the horizontal dimensions are not the full size of the mat but the pile to pile distances and the vertical dimension is the mat thickness.

Solutions

Solid element based model of mat, with proper accountability of super-structure contribution, non-conventional modeling of piles (springs) and incremental loading (allowing for load re-distribution) is a better solution. We have tried this approach in some of our projects in the past and found to perform well & feasible (practical). One of early application of such approach is Fullerton Building (37 Story, Sukhumvit 67, Bangkok).