

Procedure to Calculate Tributary Area and Vertical Spring Constants for foundation modeled with soil as elastic supports in FE based programs

Introduction

In Foundations, many times to estimate true behavior of mat; elastic property of soil is taken into consideration in FEM models. The base slab is divided into finite number of 2D plate elements representing the mat and the support condition is elastic based on the modulus of subgrade reaction of soil. Some popular FE programs do not include the facility of surface support and hence to model soil as elastic support, calculation of vertical spring stiffness at each node of the mesh becomes necessary.

The spring value shall be in Force/Unit displacement. The unit of Modulus of subgrade reaction is force/unit area/unit deflection. Hence, when vertical spring constant is to be calculated for each joint, the tributary area of mat at each node shall be calculated and then multiplied with the modulus of subgrade reaction. This procedure is simple for regularly divided meshes. However for most practical problems, it is a cumbersome process to calculate the tributary area at each node and then calculate the spring constants. Also, after the analysis is completed, the output of such programs provides only vertical spring force in force unit. For determination of actual base pressure, it becomes necessary to divide the spring force by the tributary area at each node.

Procedure

To simplify the calculation of tributary area and vertical spring constant, a simple, accurate and quicker method is suggested.

STEP 1 – Prepare the model with or without superstructure and the base modeled as 2D plate elements.

STEP 2 – Copy the model and extract the mesh at base by deleting all members/elements above base level.

STEP 3 – Provide PIN support at each node of the base and create two loading cases.

STEP 4 – In Load case 1, apply surface load equal to the magnitude of modulus of subgrade reaction on the base mat and in Load case 2, apply surface load equal to Unity on the mat.

STEP 5 – Run the model for static analysis and print the support reactions.

It is evident that, the vertical support reaction due to uniform surface load will be tributary area multiplied by the surface load. This is nothing but the spring constant when the surface loading is equal to modulus of subgrade reaction and tributary area when surface loading is unity. Thus, we achieved the spring constant and tributary area at each node. In the original model export these values as spring supports by providing appropriate command. Retain the tributary area for future use.

Alternatively, to calculate tributary areas from load case 1 only,

STEP 5 – Extract the output of support reaction for load case 1 and import it in the Excel. Divide each reaction by modulus of subgrade reaction. This gives the tributary area at each node.

STEP 6 – After the analysis of entire original model is completed; the support reaction will be spring force at each node of base mesh. To obtain base pressure magnitude, divide each spring force by corresponding tributary area obtained in the STEP – 5.