Seismic Response of Reinforced Concrete Frames on Pile Foundations

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Summary

The paper focus on the effects of soil-structure interaction on the seismic response of reinforced concrete frames founded on piles. The substructure method is adopted and 6-storeys 3-bays frames founded on 3 different two-layered soil deposits are considered. For each soil deposit two foundation typologies are adopted: mono-pile and double-pile foundations. Soil-structure interaction effects on the seismic nonlinear response of the structures are evaluated by means of incremental dynamic analyses. Results are compared with those achieved from fixed base analyses demonstrating that soil-structure interaction effects are more evident for moderate earthquakes, inducing early structural damages, and for soft soil deposits. The mono-pile foundation, suitably designed in conjunction with stiff tie-beams, is able to guarantee an efficient degree of restraint at the base of columns, comparable with that provided by the double-pile foundation.

Keywords: Pile foundations; r.c. frames; soil-structure interaction; substructure method.

1. Introduction

Reinforced concrete frames are commonly designed considering fixed restraints at the base of columns. For foundations constituted by pile groups, this assumption is deemed to be justified by the significant rotational stiffness of the foundation system whereas, in the case of mono-pile foundations, the presence of stiff tie-beams is essential to limit rotations at the base of columns.

Given that the mono-pile foundations are increasingly used in r.c. frame structures due to their ease of execution and low costs, associated to manpower for the concrete forming and the assembly of reinforcement cages, it is interesting to study the actual capability of this solution to provide a degree of restraint at the base of columns consistent with the commonly adopted design assumption of fixed base.

This paper presents an initial study on the seismic behaviour of r.c. frame structures founded on piles, comparing the sensitivity of mono-pile and double-pile foundations to interaction problems with the soil. To this purpose, 3 different soil deposits are considered in the analyses, falling within types B, C and D defined in EN1998-1 [1] and NTC2008 [2]. Analyses are carried out according to the substructure approach, using different models for the soil-foundation system and the superstructure. Results obtained from the Soil-Structure Interaction (SSI) analyses are compared with those achieved by the analyses of the fixed base structures; for each type of foundation, the role of SSI is discussed by varying the seismic intensity and the dynamic characteristics of the deposits.

2. Case studies

Case studies are constituted by 6-storeys 3-bays r.c. frames characterized by a total height h_t = 19,2 m, interstorey height h_i = 3,2 m and bay length l = 5 m (Fig. 1a). Structures were designed according to the usual assumption of columns clamped at the base. The variability of the soil conditions is considered by defining three different two-layered soil deposits falling within types B,

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