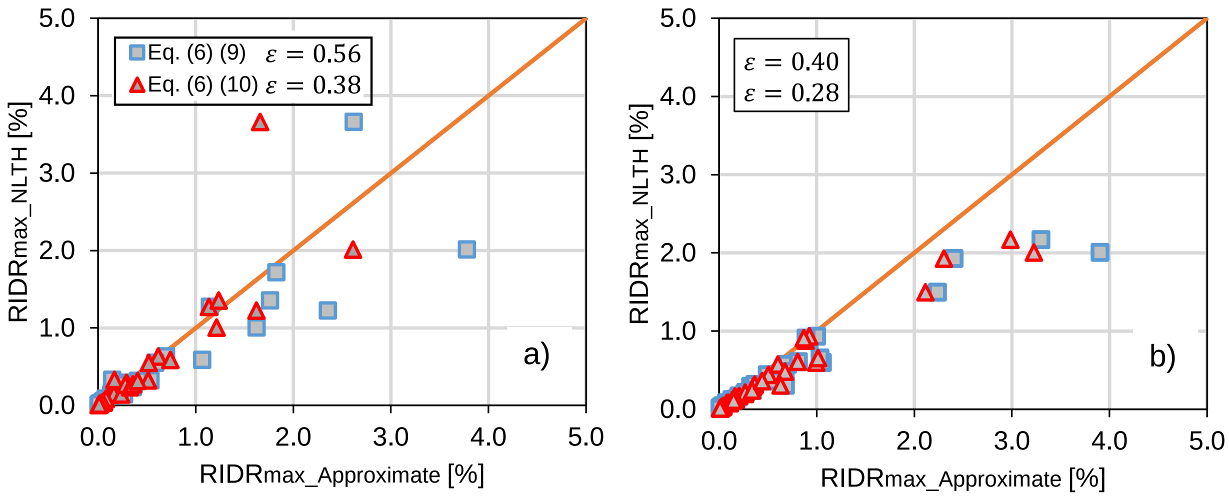

Fig. 7 Comparison of $RIDR_{max}$ computed from Eq. (6) and from NLTH analyses corresponding to building models that incorporate the interior frames: a) 3NmEI model; b) 9NmEI model

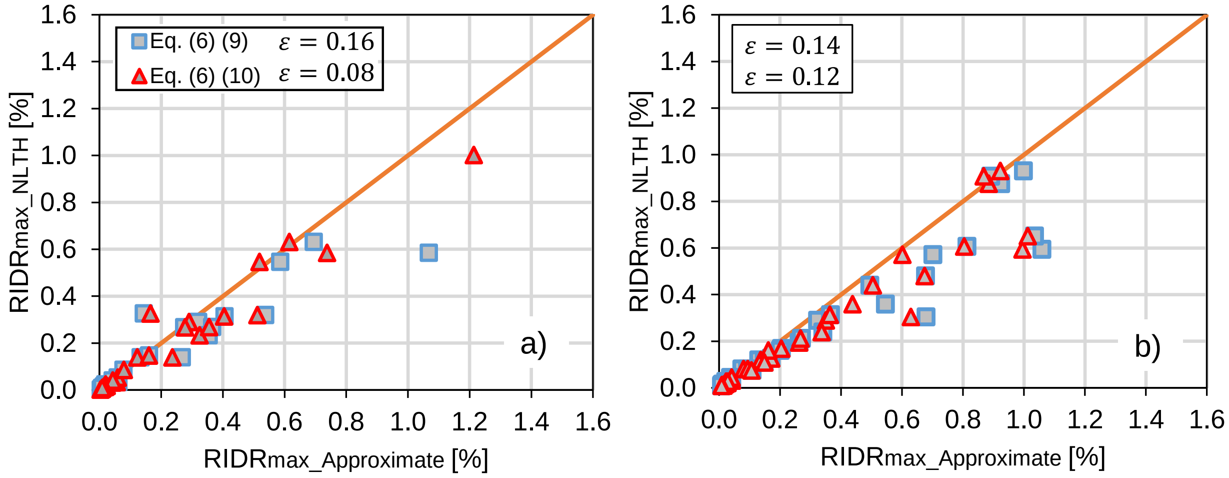

Fig. 8 Comparison of $RIDR_{max}$ computed from Eq. (6) and from NLTH analyses for $RIDR_{max}$ smaller than 1.5% corresponding to building models that incorporates the interior frames: a) 3NmEI model; b) 9NmEI model

4.2 Relationship between $RIDR_{max}$ and IDR_{max}

For rapid seismic assessment of existing buildings, it is also desirable to get an estimate of the maximum (peak) interstorey drift, IDR_{max}, demand since this engineering demand parameter is closely related structural damage. Therefore, the empirical relationship between IDR_{max} and $RIDR_{max}$, and viceversa, was examined from the results of NLTH analyses of the case-study buildings, which is shown in Fig. 9. From the figure, it can be seen that the empirical relationship follows a nonlinear trend, which can be captured by the following functional forms:

$$IDR_{max} = \theta_1 RIDR_{max}^{\theta_2} \quad (13)$$

$$RIDR_{max} = \alpha_1 IDR_{max}^{\alpha_2} \quad (14)$$

The coefficient estimates involved in Eqs. (13) and (14) were obtained through nonlinear regression analyses, which are reported in Table 1. The prediction of either IDR_{max} or $RIDR_{max}$ is indicated in red line in Fig. 9 for the case of the 6NmE building model. Similarly, confidence intervals (c.i.) of the regressed coefficients were obtained to partially account for the uncertainty of the results, with the predicted IDR_{max} or $RIDR_{max}$ using confidence intervals is also shown in orange line.

Table 1 Coefficient estimates to be used in Eqs. (13)-(14)

Building Model	Parameter	estimate	c.i.
3NmE [T_1=1.04 s]	θ_1	3.413	3.329, 3.497
	θ_2	0.392	0.371, 0.414
	α_1	0.127	0.110, 0.144
	α_2	1.799	1.727, 1.870
6NmE [T_1=1.40 s]	θ_1	4.126	4.021, 4.231
	θ_2	0.392	0.366, 0.418
	α_1	0.133	0.108, 0.158
	α_2	1.382	1.274, 1.491
9NmE [T_1=2.12 s]	θ_1	3.982	3.857, 4.106
	θ_2	0.461	0.432, 0.489
	α_1	0.136	0.108, 0.163
	α_2	1.576	1.472, 1.679
13NmE [T_1=3.04 s]	θ_1	3.606	3.502, 3.710
	θ_2	0.418	0.390, 0.446
	α_1	0.123	0.098, 0.1488
	α_2	1.754	1.642, 1.867
3NmEI [T_1=0.92 s]	θ_1	3.349	3.269, 3.429
	θ_2	0.423	0.401, 0.446
	α_1	0.126	0.109, 0.143
	α_2	1.682	1.600, 1.763
9NmEI [T_1=1.92 s]	θ_1	3.764	3.672, 3.856
	θ_2	0.476	0.455, 0.497
	α_1	0.083	0.067, 0.098
	α_2	1.889	1.791, 1.986

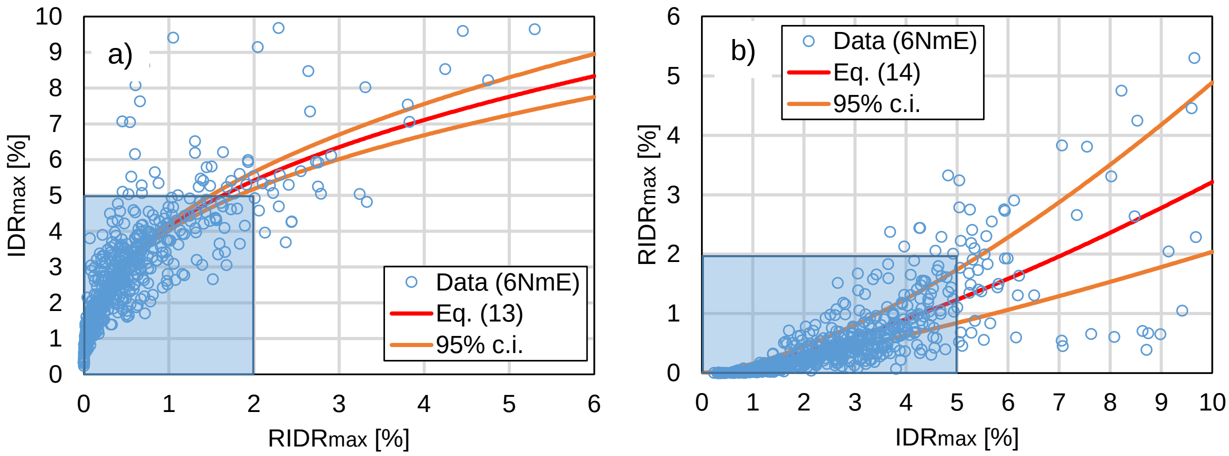

Fig. 9 a) Prediction of IDR_{max} from $RIDR_{max}$, b) prediction of $RIDR_{max}$ from IDR_{max}

In order to revise the ability of Eq. (6) to predict $RIDR_{max}$, either using Eqs. (9) or (10), and, subsequently, to predict IDR_{max}, a comparison of approximate results with respect to IDR_{max} computed from NLTH analyses is shown in Fig. 10. Additionally, the mean standard error, ε, is also reported in the figure.

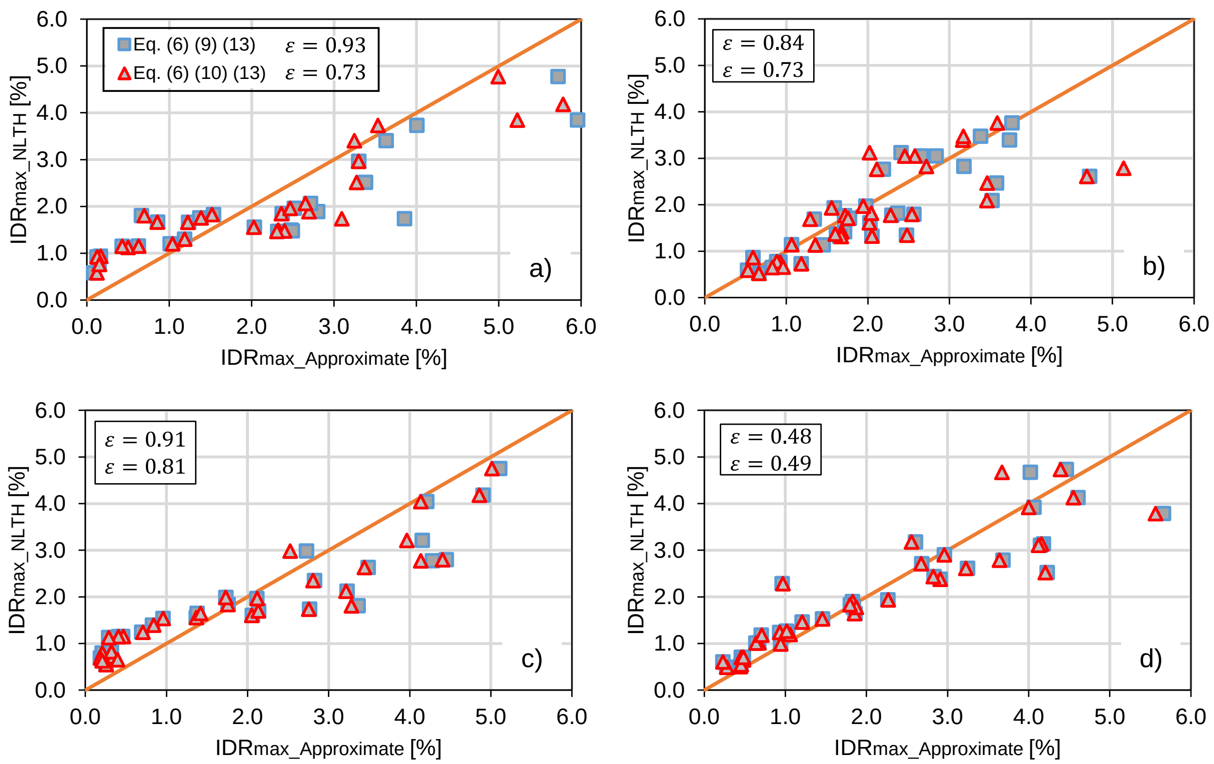

Fig. 10 Comparison of approximate IDR_{max} computed from predicted $RIDR_{max}$:
a) 3NmE model, b) 6NmE model, c) 9NmE model, d) 13NmE model

It can be seen that the use of Eqs. (6) and (7) to predict $RIDR_{max}$ yields similar standard error. It should be noted that the standard error increases as the level of predicted IDR_{max} increases; that is, the prediction of IDR_{max} using Eq. (2) is better for IDR_{max} demands smaller, or equal, than 2.0% as shown in the light blue square. It is believed that the introduced method provides good estimations of both engineering demand parameters for the preliminary seismic assessment of this type of buildings.

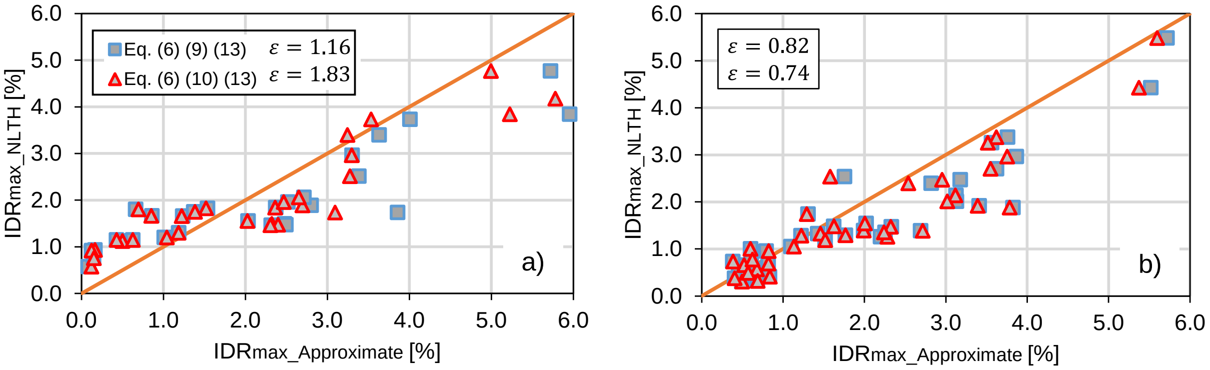

Fig. 12 Comparison of IDR_{max} computed from Eq. (6) corresponding to building models that incorporates the interior frames: a) 3NmEI model; b) 9NmEI model

5. CONCLUSIONS

This paper presented the results of an investigation on the prediction of maximum permanent interstorey drift, $RIDR_{max}$, demands for multistorey steel framed-buildings sujected to near-fault earthquake ground motions, EQGMs, including forward-directivity effects (i.e., pulse-like EQGMs). For this purpose, an approximate method previously introduced by Ruiz-García and Chora (2015) was tested in this study. The approximate method is based on a coefficient-approach that only requires basic information about the dynamic and mechanical properties of the building under consideration (i.e., normalized first-mode modal participation factor at the roof level, first-mode period of vibration, and relative lateral strength) as well as the inelastic displacement ratio, C_R. Particularly, two functional forms proposed by Ruiz-García (2011) and Iervolino et al. (2012) to obtain estimates of mean C_R for pulse-like ground motions were included in the method. The appproximate method yielded good predictions of $RIDR_{max}$, which can be used for rapid assessment of the post-earthquake buildings functionality, particularly for prediction of $RIDR_{max}$ demands smaller than about 1.5%.

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