EFFECT OF NEAR AND FAR FIELD EARTHQUAKES ON RAND CR RATIOS – CONSTANT DUCTILITY CONCEPT

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Keywords: SDOF, R Factor, CR Factor, Ductility, Near Field Motions

Previous researches show the behavior factor (R) is related to level of element plasticity, damping, and hysteresis behavior and over strength. The R factor is considered constant for all types of performance level. Thus it cannot present an efficient picture of structure and element inelasticity. This is an important defect of this factor. Despite the R factor is proposed in all seismic codes practically, there are a series of efforts to define R theoretically. The R factor based on analytical studies are divided to demand and capacity. The demand behavior factor R_d factor shows level of inelastic force to the structure during earthquake. Since the R_d is depending on type and content of earthquake, it seems that for different records, the R_d would be different. In this case the mean value is an appropriate parameter. For this reason it is expected that the R_d for single-degree-of-freedom systems (SDOF) and for near field (NF) earthquake is different than the ordinary earthquakes (OR). This aspect of subject is less considered in previous studies. In near field motions, the forward directivity effects are more important than other factors. Also fault normal component has major effects in comparison with fault parallel component. Hence in this paper the R_d corresponding to different ductility ratios have been calculated. The R_d factor is known as the R_μ factor in previous literature. Since the R_μ is related to nonlinear dynamic analysis results and the time history results are related to earthquake content, the R_μ is calculated for near and far field earthquakes simultaneously. Moreover, a sensitivity analysis has been done to assess the effect of strain hardening ration, damping and predominant pulse period to vibration period of system on the R_μ. The ratio between inelastic and elastic lateral deformation of SDOF is another factor which is considered as a part of target displacement in pushover procedure. In this paper this ratio is called The CR ratio. The CR has been defined as C_1 coefficient in FEMA440. To assess the CR, a wide range of period (0.2 to 4 sec) with four level of ductility (2, 3, 4 and 5) has been considered. After all, The CR is calculated and compared for near and fat field earthquakes respectively. Finally, a sensitivity analysis is done for the CR due to strain-hardening slope and damping. The Opensees is selected to perform nonlinear time history analysis. The bilinear elasto-plastic behavior is selected for steel material with 3% strain-hardening ratio. The damping ratio is 5% for all models. To achieve the prescribed target ductility, the yield lateral strength of SDOF system is changed with iteration procedure.

For instant the mean values for R_μ is depicted for near (SP and SN) and far field earthquakes in Figure 1. This figure shows that for short period models, R_μ, is less than ductility ratio for all types of earthquakes. Although for near field earthquakes, the period limit that change the mode of R_μ from incremental manner to constant level (while T increases) is different with far filed motions. For instant in NF-SP after T=1 sec. the R_μ approaches μ, whereas for NF-SP the transition period is 1.5 Sec. Furthermore by increasing the ductility ratio, in near filed case the difference between R_μ and μ is greater than the far filed motions. Also for short period, the R_μ reduces very rapidly and approaches unity as T approaches zero. In the long period range the R_μ approaches μ as T goes to infinity.

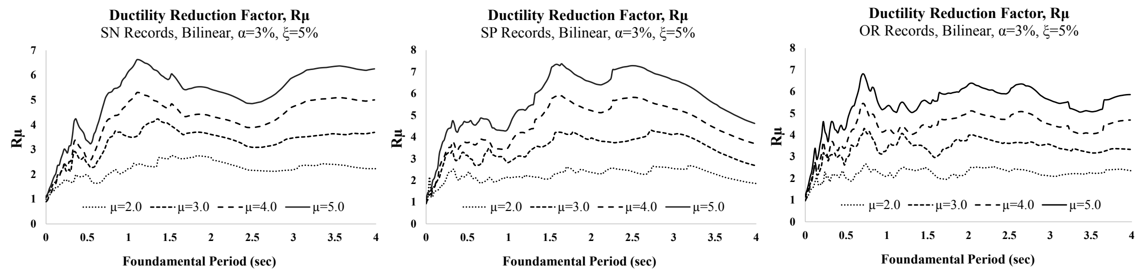

Figure 1. The R_{μ} factor for SN, SP and OR earthquakes - μ=2, 3, 4 and 5

In Figure 2, the variation of the CR ratio is depicted for to level of target ductility (2 and 5). It can be seen that for small ductility ratio, the CR is sensitive to T if the T is less than 1 sec. also the transition period is almost 1 sec for all level of ductility and earthquake. Also while the T is less than 1 sec, the SN component has a greater value than SP and OR. It means that for short period model, the CR for OR motions need to be modified in order to use it for SN-NF motions. For the structure with T>1sec, the CR for all types of earthquake approaches unity and the CR is independent of ductility level and ground motion content.

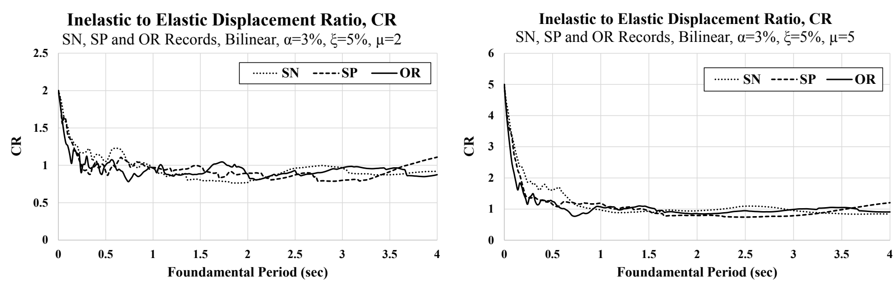

Figure 2. The CR factor for SN, SP and OR earthquakes - μ=2 and 5

It is convenience to define $CR_{SN}/CR_{O}R$ and CR_{SP}/CR_{OR} to evaluate the CR ratio and compare the results of SN and SP with OR earthquake. This ratio is depicted in the Figure 3. It can be seen that for T<1sec period this ratio is greater than unit. While the ductility level increases, this ratio decreases.

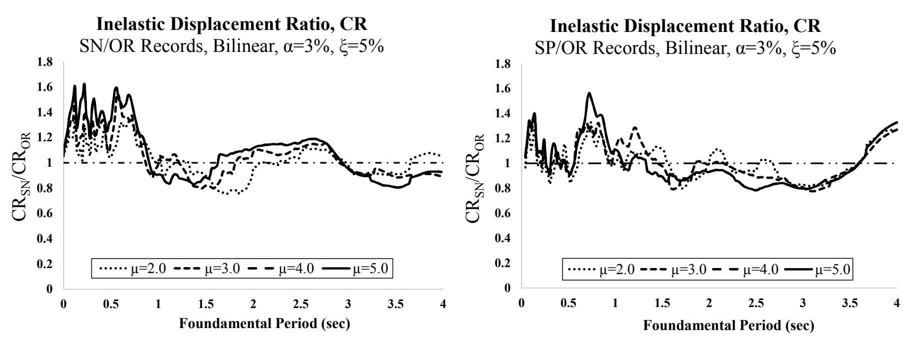

Figure 3. The ratio of CR factor for SN, SP and OR earthquakes - μ=2, 3, 4 and 5

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