Design of Miniaturized Printed QuasiYagi Antenna

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Abstract

A compact planar printed quasiYagi antenna is presented. The proposed antenna consists of a microstrip line to slotline transition structure, a driver dipole and two parasitic strips. The driver dipole is connected to the slotline through coplanar stripline (CPS). The ground plane is modified by symmetrically adding two extended stubs to reduce the lateral size. Experimental and simulated results show that the proposed quasiYagi antenna has a wide bandwidth and good unidirectional radiation characteristics. Compared with conventional printed quasiYagi antennas, the width of the proposed quasiYagi antenna is reduced by approximately 16.7%. The proposed antenna presents an excellent end fire radiation with a front to back ratio greater than 10 dB. Its measured bandwidth is from 3.6 11.6 GHz with a ratio of about 3.22: 1. A moderate gain, which is better than 4 dBi, is obtained.

Introduction

Recently, the nonlinear static analysis (NSA) method has emerged as an attractive method for evaluating the performance of new and existing buildings. This is primarily because of the ability of the NSA method to provide estimates of the expected inelastic deformation demands and to help identify design flaws that would be otherwise ob scured in a linear analysis of the building. In addition, the features of the NSA method are available to the structural engineer without the modeling and computational effort of a nonlinear time-history analysis. Therefore, extensive research efforts have been devoted to investigatingthe structural behavior under seismic loads by using pushover analysis.

Sung et al. (2013) [1] investigated the shear failure behavior of beam-column joints (BCJs) of RC frame structures by the means of nonlinear static pushover analysis (NSPA). The authors proposed a new NSPA procedure to assess effectively the shear failure of BCJs and its seismic capacity and the progressive failure of the joints. Furthermore, they provided novel plastic hinges (PHS) characteristics of BCJs and an innovative cross-strut model to simulate detailed joint behavior in NSPA. The analytically derived pushover curves were compared to three different full-scaled RC frames to validate the proposed methodology

Hassaballa et al. (2014) [2] performed a 3D NSPA to study the performance of existing four-storey RC flat slab building in both positive and negative X and Y directions separately. The evaluation was carried out by using SAP2000 software (Ver. 14) [3]. It was observed from the analysis that the building was not safe and needed retrofitting in the X-direction because there were some elements exceeded the limit level between life safety (LS) and collapse prevention (CP), whereas, all structural elements did not reach the limit in Y-direction

Maske et al. (2014) [4] performed 3D NSPA on 5 and 15 storeys frame structures using SAP2000 software (Ver. 14). A detailed description of pushover method and capacity curve properties was presented. In addition, the authors evaluated different parameters that affected seismic assessment of frame structures, e.g. pushover and capacity curves. It was concluded that the considered case studies performed reasonably under seismic loads

Choudhary and Wadia (2014) [5] investigated the effect of shear walls on the seismic performance of the RC frame structures. Two case studies were considered in the analysis, in which one was symmetrical building and the other was unsymmetrical building (i.e. L-shaped building). It was found that providing shear walls led to a significant decrease in both buildings. Moreover, placing the shear walls in the short direction is mandatory for the unsymmetrical building since they provide more reduction in roof displacement.

Aleksieva (2015) [6] conducted a comparative study between the NSPA and incremental dynamic analysis (IDA) to investigate the structural behavior of a RC threestorey frame building under the seismic loading. The aim of the paper was to highlight the advantages of each method and their applicability in structural seismic design. The OpenSees software [7] was used to conduct the analysis of the building. It was concluded that the pushover analysis produced accurate results in the elastic region, whereas the results were very conservative in the nonlinear region.

Keerthan and Babu (2016) [9] carried out a pushover analysis on 3D 10 storeys RC frames in order to investigate the effect of mass irregularities on the structural behavior under severe earthquakes. ETABS software (Ver. 9.7) was used to carry out the pushover analysis. The main findings of study were that the increase in lateral displacement of mass irregular frame was promotional to the heavy mass floor level. Furthermore, the mass irregular RC frames experienced significant interstorey drifts compared to the regular RC frames. The focus of this paper is on the evaluation of the nonlinear performance of regular multi-storey reinforced concrete buildings using the NSA and pushover analysis under the loads of the IBC2009 [10] and the Regulations of the Egyptian Society for Earthquake Engineering (ESEE) [11]. Moreover, the obtained pushover curves and plastic hinges distributions are used to compare between the IBC2009 code and ESEE regulations. The outcome of this study is to check the vulnerability of both codes, and to provide useful information for further seismic designs in UAE.

Pushover Analysis

Pushover analysis is a static nonlinear procedure in which the magnitude of the lateral force is incrementally increased, maintaining the predefined distribution pattern along the height of the building. With the increase in the magnitude of the loads, weak links and failure modes of the building are found [12].

Pushover analysis can determine the behavior of a building, including the ultimate load and the maximum inelastic deflection. Local nonlinear effects are modeled and the structure is pushed until a collapse mechanism gets developed. At each step, the base shear and the roof displacement can be plotted to generate the pushover curve. It gives an idea of the maximum base shear that the structure was capable of resisting at the time of the earthquake. For regular buildings, it can also give an estimate about the global stiffness of the building [13].

In this paper, the lateral loads were applied monotonically in a step-by-step nonlinear static analysis. The applied lateral loads were accelerations in the x direction representing the forces that would be experienced by the structures when subjected to ground shaking. Under incrementally increasing loads some elements may yield sequentially. Consequently, at each event, the structures experiences a stiffness change as shown in Figure 1, where IO, LS and CP stand for immediate occupancy, life safety and collapse prevention, respectively.

Earthquake Loads

The seismic loads applied on the frame building are calculated according to the rules

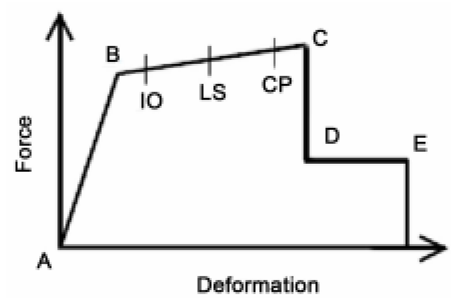


Figure 1. Force-deformation for pushover hinge [14].

which are given in the International Building Code IBC2009 and the Regulations for earthquake-Resistant Design of Buildings in Egypt (ESEE). The loads obtained by IBC2009 are calculated directly by the SAP2000 software, whereas, the seismic loads from ESEE regulations are calculated manually

Seismic Loads According to IBC2009 Code

In this study, pushover analyses were performed on four concrete frame models which are consisted of two bays. The typical bay width and storey height of the four models are 5.0 and 3.0 meters, respectively. The ground floor height is 5.0 meters to take into account the foundation depth. Since the common soils in UAE are generally classified as weak soils, the buildings are usually founded on piles or raft foundations. This is reflected in the prototype buildings by choosing the support condition of the columns to be fixed. The four models neglect the effects of torsion in buildings subjected to earthquakes assuming that the center of mass of the building coincides with the center of rigidity of its columns. The selected numbers of storeys of the RC buildings are 5, 15, 20 and 30 storeys as shown in Figure 2. The models are analyzed and designed under gravity and seismic loads using SAP2000 software (Ver.15) [17]. The following assumptions are considered for lateral elastic analysis: In this study, pushover analyses were performed on four concrete frame models which are consisted of two bays. The typical bay width and storey height of the four models are 5.0 and 3.0 meters, respectively. The ground floor height is 5.0 meters to take into account the foundation depth. Since the common soils in UAE are generally classified as weak soils, the buildings are usually founded on piles or raft foundations. This is reflected in the prototype buildings by choosing the support condition of the columns to be fixed. The four models neglect the effects of torsion in buildings subjected to earthquakes assuming that the center of mass of the building coincides with the center of rigidity of its columns. The selected numbers of storeys of the RC buildings are 5, 15, 20 and 30 storeys as shown in Figure 2. The models are analyzed and designed under gravity and seismic loads using SAP2000 software (Ver.15) [17]. The following assumptions are considered for lateral elastic analysis:

1. Shear deformation effects are neglected.
2. Non-structural elements and in-fill walls are neglected.
3. Buildings are modeled as 2-D frames with fixed supports at the foundation level.
4. The out-of-plane deformations are absorbed by the rigid horizontal diaphragms.
5. Cracked sections for beams and columns are used in the analysis.
6. The floor diaphragms are rigid enough to distribute uniformly the lateral loads on the vertical elements.

Results and Discussion

This part presents the results of the analysis and design of considered RC buildings. It also provides a through comparison between the IBC2009 code and the ESEE regulations to investigate which code produces buildings that are more vulnerable.

Beams Sections Design

All the beam elements are designed to withstand the maximum bending moments and shear forces applied on them. The section properties for IBC2009 code and ESEE regulations are shown in Table 2; both codes have the same reinforcement for beams. Columns Sections Design All the columns elements are designed to withstand the maximum bending moments and axial forces that are applied on them

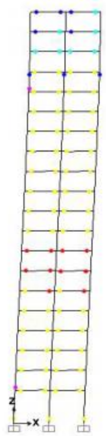
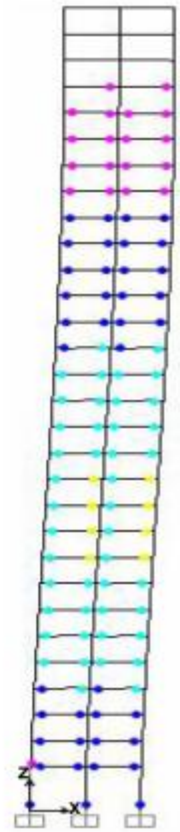


Figure 12. Distribution of hinges in 20-storey building using IBC2009 (E).



From distribution of hinges for 15-storey, it can be noticed that the plastic hinges were located at the fourth, fifth and sixth levels with severe failure. In addition, most of plastic hinges occurred in the beams, which satisfies the weak beam-strong column criteria. Moreover, critical section was located on the columns of the tenth floor, as for these columns the load was released which is an indication for the near failure for the soft storey in building.

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