Design of non-structural elements for buildings: A review of codal provisions

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Non-structural elements of a building are not a part of the main load-resisting system. Therefore, these are often neglected from the structural design point of view. Performance in the past earthquake clearly pointed out that in view of the absence or inadequacy of design provisions for non-structural elements and their attachments it has resulted in poor performance of several life line buildings. In India too, non-structural damages are often observed in the earthquakes but are overlooked owing to the obvious attention to the huge loss of human lives and structural damage. Moreover, provisions relating to non-structural element in Indian seismic codes (IS 1893) are inadequate or practically non-existent. This paper reviews the design philosophy and design provisions of several international seismic codes, and compares design lateral forces recommended in these codes.

Keywords: *Non-structural elements, codal provisions, seismic design, relative displacement, lateral forces*

Non-structural elements are those which are attached to or housed in a building or building system, but are not part of the main load-resisting structural system of the building. These can be of three types, namely:

(*i*) architectural elements, for example, parapets, penthouses, appendages and ornamentations, veneer, cladding systems, suspended ceiling, sign boards, etc.,

(*ii*) mechanical components, for example, boilers, storage tanks, piping systems, fire protection systems, and

(*iii*) electrical components, for example, electric motors, light fixtures, computers and data acquisition systems, etc.

During an earthquake, the above elements are subjected to large inertia forces and/or relative displacements depending on their nature. There are three types of risk associated with the earthquake damage of non-structural elements: loss of life or injury to building occupants, loss of property especially in commercial buildings where the cost of non-structural elements may be as high as 75 percent of the total cost of the building, and impairment or loss of function of an important building or lifeline structure, for example, fire resisting system, communication facilities, telecom centre, which should be functional just after an earthquake. During the 1994 Northridge earthquake in Los Angeles, California, several major hospitals (for example, Olive View, Holy Cross Hospital, etc.) were effectively shut down for a week after the earthquake due to the damage of non-structural elements[1]. In spite of all these consequences, over the years, design of non-structural elements was overlooked as compared to the design of structural elements because the focus of engineers had been the prevention of structural failure first, and also because the non-structural elements are not permanently attached to the buildings and often added after the construction is complete.

In India, several water tanks on top of building, *Fig* 1, and sign boards, *Fig* 2, located at the upper floors collapsed during 2001 Bhuj earthquake. Unfortunately, the loss of human life and structure were so widespread that the non-structural damage was not paid attention to. Design provisions for non-structural elements in Indian seismic code IS 1893 are either non-existent or too primitive. This paper reviews and compares the design provisions of non-structural elements in different seismic codes and provides a basis of making a draft code for Indian scenario.

Developments in codal provisions: Brief historial background

A great deal of research effort has been devoted over the past 40 years to the development of rational methods for the seismic analysis of non-structural elements. However, earlier efforts have been focussed on the safety of critical equipments

Fig 1 Failure of overhead tank in Bhuj earthquake, 2001
(Photo credit: C.V.R. Murty[10])

such as piping and control systems in important structures, for example, nuclear power plants. Therefore, these methods have been successfully applied in the analysis of such facilities but have not been used extensively for the analysis of non-structural elements in the conventional buildings.

The San Francisco (1906), Santa Barbara (1925) and Long Beach (1933) earthquakes exposed the vulnerability of brick parapets and exteriors walls. In 1927, provisions on non-structural element were included for the first time in an Appendix of the Uniform Building Code (UBC, 1927) as follows:

> *"(b) bonding and tying. All buildings shall be firmly bonded and tied together as to their parts and each one as a whole in such manner that the structure will act as a unit. All veneer finish, cornices and ornamental details shall be bonded in the structure so as to form an integral part of it. This applies to the interior as well as the exterior of the building[2]."*

Afterwards it was recognised that like structural elements, non-structural elements should also be designed for lateral force which is proportional to the weight of the non-structural element itself. Therefore, design horizontal lateral force for non-structural elements and its connections was recommended as $F = CW$ in the 1935 edition of UBC[2] and remained practically unchanged until UBC 1997[3]. The provisions were mainly confined to architectural elements, towers, tanks, contents, chimneys, penthouses, etc. But these provisions were not mandatory at that time because these were given in the appendix of the code and remained there until 1961 edition of UBC when the seismic provisions for non-structural element were recommended in the main body of the code for the first time[2]. This code also addressed the requirement of designing the anchorage of non-structural elements. The Alaska (1964) and the San Fernando (1971) earthquakes brought the non-structural element under limelight. Lessons learned from these and subsequent earthquakes led to the incorporation and continual modification of several international building codes. In the 1967 edition of UBC "connection for exterior panels" were incorporated after the failure of exterior precast wall panels in the 1964 Alaska earthquake[4]. The 1971 San Fernando earthquake demonstrated the failure of suspended ceiling systems, metal book shelving in libraries and mechanical equipments. And the subsequent edition of UBC (UBC 1973) included "storage racks", and "suspended ceiling framing systems" in the design provisions of non-structural elements[4]. In the 1976 edition of UBC, provisions for mechanical equipment were incorporated as "the design of the equipment and machinery and their anchorage is an integral part of the design and specification of such equipment and machinery[4]." In this code "importance factor" was explicitly included for the first time for non-structural elements. Fire sprinkler and access floor systems were included in 1985 UBC while signs and billboards, major piping and ducting, boilers, heat exchangers, chillers, pumps, motors, cooling towers, etc. were incorporated in the 1988 UBC[4]. The 1991 UBC first addressed the requirement of relative displacement of equipment attachment[4].

An important issue in designing the non-structural elements and their attachments is the amplification of lateral force that increases with the vertical location of the non-structural elements. This was first recommended in terms of amplification factor in ATC-3-06[5] for "mechanical and electrical components and their attachments" only. Such amplification factor was later recognised by 1994 NEHRP provisions[6], UBC 1997[3], Eurocode 8 (DD-ENV 1998-1-2)[7] and IBC 2000[8]. All these codes consider trapezoidal distribution of floor accelerations, linearly increasing from the acceleration at the ground to the acceleration at the roof. Apart from this, 1997 edition of UBC[3] added the concept of near fault, soil effect, use of strength design level loads, and in-structure amplification factor. In-structure amplification factor takes care of the amplification of force experienced by flexible components.

Merely designing the non-structural elements and their connections based only on

Fig 2 Failure of signboard in Bhuj earthquake, 2001
(Photo credit: Alok Goyal[10])

Table 1: **Comparison of design force values for non-structural element and the building itself**

Code	*Design force on non-structural elements* *Parapet at ground level(F_{pg})*	 *Parapet at roof level(F_{pr})*	*Design force on building*	*Ratio of coefficient of F_{pg} to V_B*	*Ratio of coefficient of F_{pr} to V_B*
Eurocode 8	$F_{pg} = \frac{S_a W_p \gamma_a}{q_a} = \frac{(0.46)W_p \times 1}{1} = 0.46W_p$ where, $S_a = \alpha S\left[\frac{3\left(1+\frac{z}{H}\right)}{1+\left(1-\frac{T_a}{T_1}\right)^2} - 0.5\right]$ $= 0.36\times 1\left[\frac{3\left(1+\frac{0}{9}\right)}{1+\left(1-\frac{0.07}{0.40}\right)^2} - 0.5\right]$ $= 0.46$	$F_{pr} = \frac{1.1\times W_p \times 1}{1} = 1.10W_p$ where, $S_a = 0.36\times 1\left[\frac{3\left(1+\frac{9}{9}\right)}{1+\left(1-\frac{0.07}{0.40}\right)^2} - 0.5\right] = 1.10$	$V_B = 0.14W$	3.3	7.8
UBC 1997	$F_{pg} = \frac{a_p C_a I_p\left(1+3\times\frac{h_x}{h_r}\right)W_p}{R_p}$ $= \frac{2.5\times 0.6\times 1\left(1+3\times\frac{0}{9}\right)W_p}{3} = 0.50\ W_p$ where, $C_a = 0.40\times 1.5$	$F_{pr} = 2.5\times 0.6\times 1\left[\frac{1+3\times\frac{9}{9}}{3}\right]W_p$ $= 2.00W_p$	$V_B = 0.18W$	2.8	11.1
IBC 2003	$F_{pg} = \frac{0.4a_p S_{DS} W_p\left(1+2\times\frac{z}{h}\right)}{\frac{R_p}{I_p}}$ $= \frac{0.4\times 2.5\times 1.33W_p\left(1+2\times\frac{0}{9}\right)}{\frac{2.5}{1}} = 0.53\ W_p$ where, $S_{DS} = \frac{2}{3}F_a S_S = \frac{2}{3}\times 1\times 2.0 = 1.33$	$F_{pr} = 0.4\times 2.5\times 1\times W_p\left[\frac{1+2\times\frac{9}{9}}{\frac{2.5}{1}}\right]$ $= 1.6\ W_p$	$V_B = 0.20\ W$	2.6	8.0
NZS 4203:1992	$F_{pg} = C_{ph} W_p R_p = 0.26\times W_p\times 1 = 0.26W_p$	$F_{pr} = 0.77\times W_p\times 1 = 0.77\times W_p$	$V_b = 0.08W$	3.2	9.6
IS 1893	$F_{pg} = 5A_h W_p = 5\times 0.09W_p = 0.45W_p$ Where, $A_h = \frac{\frac{Z}{2}\times I\times\frac{S_a}{g}}{R} = \frac{0.36}{2}\times 1\times\frac{2.5}{5} = 0.09$	$F_{pr} = 5\times 0.09Wp = 0.45W_p$	$V_b = 0.09W$	5.0	5.0

Note: Seismic weight of the building is W and that of the parapet is Wp.

the seismic design forces is not considered adequate for non-structural elements that are attached to the structure at multiple points, for example, piping system, stairwells, cladding, etc. Hence, researchers came up with the seismic relative displacement equations as a part of study and workshop sponsored by National Centre for Earthquake Engineering Research (NCEER)[9]. This equation was incorporated in 1994 NEHRP provisions[6] and IBC 2000[8].

Types of non-structural elements

Depending on their response during earthquake shaking, non-structural elements can be divided into three categories, namely, deformation sensitive, acceleration sensitive, and both deformation and acceleration sensitive elements. Partition wall, piping system running floor to floor, etc., are deformation sensitive elements. Good performance of this type of elements is ensured in two ways, namely, by limiting inter-storey drift of the supporting structure which governs for important elements, and by designing the elements to accommodate the expected lateral displacement without damage[11]. Acceleration-sensitive elements are parapets, appendages, HVAC equipments, boilers and furnaces, etc. These are vulnerable to shifting and overturning. Their performance during earthquake can be enhanced by designing proper connections and bracing systems. Another classification used for non-structural elements is based on loss incurred after their failure during earthquake shaking (for example, FEMA 274[12]). The classification includes failure which represents a life hazard, failure which represents primarily economic loss, and the failure which represents loss of building function.

Design philosophy and design provisions in various seismic codes

The response of a non-structural element depends on the response of its supporting building, size and weight of element, location of the element in the building (for example, the first floor or roof), flexibility of the component, etc.

Response of the building itself depends on ground motion, soil condition, ductility of the building, etc. Based on the above factors, several seismic codes now have provisions for seismic design of non-structural elements. Most of these provisions are based on equivalent lateral force method, where the non-structural element is designed for a lateral seismic force that is a fraction of the weight of the non-structural element.

Eurocode 8[13]

The design provisions in Eurocode 8 take into account ground motion, structural amplification, soil factor, and self weight, flexibility and importance of the non-structural element. This code requires very important and /or dangerous non-structural elements to be analysed by making a realistic model of the relevant structures and using floor response spectra. For other elements that may cause risks to persons, or affect the main structures or services of critical facilities be verified to resist design seismic load, F_a, as follows:

$$F_a = \frac{S_a \gamma_a}{q_a} W_a \qquad \text{...(1)}$$

and

$$S_a = \frac{a_g}{g} S \left[\frac{3\left(1 + \frac{z}{H}\right)}{1 + \left(1 - \frac{T_a}{T_1}\right)^2} - 0.5 \right] \qquad \text{...(2)}$$

where,

γ_a = importance factor which ranges form 1.5 for important and/or hazardous elements to 1.0 for all other elements

W_a = weight of the element

a_g = design ground acceleration

g = acceleration of gravity

T_a = fundamental period of the non-structural element

T_1 = fundamental period of the building in the relevant direction

z = height of the non-structural element above the base of the building

H = total height of the building

S = soil factor

q_a = behaviour factor for non-structural elements equal to either 1.0 or 2.0 depending on their behavior during earthquake shaking. For example, behaviour factor for cantilever parapets or ornamentation, signs and billboards, chimneys, and tanks is assigned as 1.0 while that for exterior and interior walls, partitions and facades, anchorage elements for false ceilings and light fixtures is assigned as 2.0.

Equation (2) takes into account the relative flexibility of non-structural element as compared to that of its supporting structure. Since the non-structural elements are generally rigid as compared to the supporting structures, that is, $\frac{T_a}{T_1} \approx 0.0$, Equation (2) can be approximated as

$$S_a \approx \left(\frac{a_g}{g}\right) S \left[(1.5)\left(1 + \frac{z}{H}\right) - 0.5 \right] \qquad \text{...(3)}$$

that is, for ground storey ($z = 0.0$) input acceleration is same as the peak ground acceleration

$$S_a \approx \left(\frac{a_g}{g}\right) S$$

and for the non-structural element attached at the roof ($z = H$) the input acceleration is 2.5 times the ground acceleration. Flexible non-structural elements are subjected to larger acceleration than the rigid elements.

Uniform Building Code (UBC 1997)[3]

The Uniform Building Code (UBC) recommends design seismic forces, F_p, for "elements of structures and their attachment, permanent non-structural components and their attachment, and the attachments for permanent equipment supported by a structure." Attachments of furniture and floor or roof mounted equipments weighing less that 181 kg are exempted from this requirement. Attachments include anchorages and bracing system. Frictional resistance due to gravity loads is to be neglected. F_p can be calculated using two alternate equations as follows:

$$F_p = 4.0 C_a I_p W_p \qquad \text{...(4)}$$

Alternatively,

$$F_p = \frac{a_p C_a I_p}{R_p} \left(1 + 3 \times \frac{h_x}{h_r} \right) W_p \qquad \text{...(5)}$$

In the latter case,

$$0.7 C_a I_p W_p \le F_p \le 4.0 C_a I_p W_p \qquad \text{...(6)}$$

where,

C_a = horizontal seismic coefficient (basically the peak ground acceleration) for a particular soil profile type and zone factor

a_p = component amplification factor, varies between 1.0 to 2.5 depending on the dynamic properties of component and the supporting structure

I_p = importance factor of the non-structural element

R_p = component response modification factor varies between 1.5 and 4.0

W_a = weight of the element.

Equation (4) is easier to apply and gives conservative results as it considers that the non-structural element will be subjected to four times the peak ground acceleration irrespective of its locations in the building. On the other hand, Equation (5) is more accurate as it considers different parameters on which the response of non-structural elements is dependent. It assumes that a non-structural element attached to the roof of a building will experience four times the acceleration that a similar element attached to the ground floor of the same building experiences. Equation (6) is the lower ($0.7C_aI_pW_p$) and upper ($4.0C_aI_pW_p$) bound of design seismic force considering the element as rigid (fundamental period < 0.06 s) and flexible (fundamental period > 0.06 s), respectively.

UBC 1997 also specifies that the lateral force design of essential or hazardous facilities should consider the effect of relative motion of the points of attachment to the structure. The element should accommodate "the maximum inelastic response displacement, Δ_m," which shall be computed as:

$$\Delta_m = 0.7R\Delta_s \qquad ...(7)$$

where,

Δ_s = total drift or total storey drift that occurs when the structure is subjected to the design seismic forces

R = inherent overstrength and global ductility of the supporting structure.

International Building Code (IBC 2003)[14]

International Building Code 2003 recommends that the non-structural element should be designed to satisfy both seismic force and seismic relative displacement requirements. The design seismic force is defined by the following equations:

$$F_p = \frac{(0.4a_pS_{DS}W_p)}{\dfrac{R_p}{I_p}}\left(1+2\frac{z}{h}\right) \qquad ...(8)$$

and

$$0.3S_{DS}I_pW_p \le F_p \le 1.6S_{DS}I_pW_p \qquad ...(9)$$

where,

S_{DS} = spectral acceleration at short period = $(2/3)S_{MS}$; $0.4S_{DS}$ represents the peak ground acceleration

S_{MS} = mapped considered earthquake spectral response acceleration for short periods adjusted for site class effect

R_p = component response modification factor which varies between 1.5 to 5.0

I_p = importance factor of the component that ranges from 1.0 for typical components in normal service to 1.5 for components containing hazardous substances

z = height of point of attachment of component with respect to the base. For components at or below the base z shall be taken as 0.0

h = average roof height of the structure with respect to the base

W_p = weight of the component

a_p = component amplification factor to account for flexibility of the non-structural element. $a_p = 1.0$ is assigned for equipment generally regarded as rigid (fundamental period < 0.06 s) and rigidly attached, $a_p = 2.5$ is for equipment generally regarded as flexible (fundamental period > 0.06 s) and flexibly attached.

Equation (8) is recommended to compute design seismic force assuming that input acceleration at the ground floor is equal to the peak ground acceleration ($0.4S_{DS}$) and that at the roof of the building is equal to three times the peak ground acceleration, that is, $1.2S_{DS}$. In the intermediate floors input acceleration varies linearly between $0.4S_{DS}$ to $1.2S_{DS}$. The force, F_p, shall be considered acting independently on the two orthogonal directions in combination with service loads associated with the non-structural element.

IBC 2003 also recommends minimum design seismic relative displacement, D_p, between two connections of a component having multiple connections. For two connection points on the same structure or the same structural system but attached at different heights, the non-structural element should be designed to accommodate relative displacement due to design seismic load determined by elastic analysis, and multiplied by deflection amplification factor, C_d, of the building. However, in absence of elastic analysis, storey drift is considered as the basis to compute the relative displacement. Similarly, for two connection points on separate structures, or separate structural systems, connected at different heights, the design displacement shall be sum of the absolute displacement due to design seismic load determined by elastic analysis, and multiplied by deflection amplification factor, C_d, of the building. The effect of seismic relative displacements

Table 2: Parameters of different codes used for the case studies

Code	*Type of soil*	*Seismic zone*	*Type of building (SMRF)*	*Importance factor (I) or risk factor of the building (R)*	*Fundamental period of the building (T_1), s*	*Natural period of the element (T_p), s*	*Importance factor of the element, I_p*
Eurocode	Type A (Rock)	PGA = 0.36g	Behaviour factor = 5.4	1	0.4	0.07	1
UBC 1997	Type S_B (Rock)	Zone 4, Z = 0.4	R = 8.5	1	0.4	0.07	1
IBC 2003	Type B (Rock)	MCE = 2g	R = 8.0	1	-	-	1
NZS 4203:1992	Category (a) (Rock or very stiff soil)	Z = 1.2	μ = 5	1	0.4	0.07	1
IS 1893	Type 1, rock or hard soil	Zone V (Z = 0.36)	R = 5	1	0.4	-	-

SMRF: Special moment - resisting frame

Note: Eurocode has recommended that the hazard parameter, a_{gR}, for a country may be derived from zonation maps in its National Annex corresponding to the reference probability of exceedance in 50 years or a reference return period. Here, for the case studies, a_{gR} is taken as 0.36 g shall be considered in combination with displacements caused by other loads as appropriate.

New Zealand Code (NZS 4203:1992)[15]

The New Zealand code specifies seismic forces on all parts of structures, including permanent non-structural components and their connections, and the connections for permanent services equipment supported by the structures as follows:

$$F_{ph} = C_{ph} W_p R_p \qquad \text{...(10)}$$

$$F_{pv} = C_{pv} W_p R_p \qquad \text{...(11)}$$

where,

F_{ph} = horizontal seismic forces on the non-structural element
F_{pv} = vertical seismic force
R_p = risk factor equal to 1.0 or 1.1 depending on category of the non-structural element
W_p = weight of the non-structural element
C_{ph} = horizontal seismic coefficient
C_{pv} = vertical seismic coefficient.

This code also recommends that the connection for regular structure should be designed by capacity design concept. In situations where, in the event of failure there is a risk to persons, the design forces of connection shall be 1.5 times the design force of the component or the connection shall be detailed for displacement ductility factor not less than 2.0.

> **Provision of IS 1893 : 2002 for seismic design of non-structural elements are highly inadequate.**

Indian Standard IS 1893 (Part 1): 2002[16]

According to clause 6.1.6 of IS 1893 (Part 1): 2002 "equipment and other systems, which are supported at various floor levels of structure, will be subjected to motions corresponding to vibration at their support points." In important cases, it is recommended to obtain floor response spectra for design. Clause 7.12.2 states that the vertical cantilever projections attached to buildings and projecting above the roof shall be designed for five times the horizontal seismic coefficient and all the horizontal projections shall be designed for 10/3 times the horizontal seismic coefficient. Provisions in this code for the seismic design of non-structural elements are therefore highly inadequate.

Comparison of codal provisions

Different codes assume that floor acceleration varies from the ground to the roof linearly; the acceleration at the roof is generally assumed as two to four times that at the ground level. In most of the seismic codes, a response modification factor is also included to account for the overstrength and inelasticity of the non-structural element and/or its connections. In general, the design seismic force specified in the above codes should be applied for the non-structural element if its mass and/or stiffness does not affect those of the main structure significantly. When the mass and/or stiffness of the non-structural element affect significantly those of the supporting structure, structure and non-structural element should be analysed together considering the flexibility of the elements and its support.

A comparison of the design force values arrived at after applying provisions in different codes for a parapet on roof and at ground floor of a 9-m high residential building is shown in *Table* 1. The total design horizontal seismic force for different codes for the building itself are also shown in *Table* 1. The building is assumed to be a special RC moment resisting frame (SMRF) building situated on a rocky or hard soil site in a high seismic zone in the respective country. For UBC 1997, the near source factors, N_a and N_v, are 1.5 and 2.0, respectively, assuming that the building is situated within 2 km of the "Type A" seismic source which is capable of producing large magnitude events $(M_m \geq 7.0)$ and that have a high seismic activity (slip rate $\geq$ 5 mm/year). The parameters used in the case studies are given in *Table* 2. The observations made are given below.

(*i*) When the element is supported on the ground floor, design horizontal force ranges from 26 to 53 percent of weight of the element. The variation is due to different seismic conditions in different countries.

(*ii*) Design of a non-structural elements attached on the roof using UBC code requires design horizontal force of 200 percent of the weight of the non-structural element. Since IBC 2003 is the successor code of UBC, it has moderated the amplification of design seismic force of the element when it is attached on the upper floor. Therefore, comparing IBC 2003, Eurocode 8 and NZS 4203 it can be concluded that the design lateral force ranges from 80 to 150 percent of the weight of the element.

(*iii*) The Indian code is different since it does not account for the amplification of design horizontal force with the increase of the height of point of attachment of the element to the building. Therefore, design horizontal force for the non-structural element according to Indian code is not comparable to the other seismic codes if the non-structural element is located at upper floor of the building.

(*iv*) Typically, a building is designed for total horizontal force of 10 to 20 percent of the weight of the building, while a non-structural element on the ground floor is designed for about 40 to 50 percent of the weight of the element, and for 100 to 150 percent if it is located on the roof. In other words, design lateral force coefficient for non-structural elements is several times that of the supporting structure.

Summary and conclusion

Earthquake design of non-structural elements is quite crucial for important buildings and lifeline structures. In earlier years, the focus of seismic design was on the design of structural elements. However, as progress was made with regard to seismic safety of main structures, and failures of non-structural elements were observed in the past earthquakes, seismic codes incorporated design provisions for these elements. This paper reviewed development of codal provisions. It discussed the design philosophy and provisions of different seismic codes, and compared design lateral force recommended in these codes. Most of these codes provide simplified method to obtain design seismic force which depends on the response of its supporting building, size and weight of the element, relative location of the element in the building, flexibility of the component, etc. Codes generally recommend that the non-structural elements should be designed for much higher seismic coefficient values than the supporting building itself. International Building Code has incorporated provisions for displacement sensitive non-structural elements also. Most of the codes also recommend the use of floor response spectrum for important and dangerous non-structural elements. Indian standard needs to be modified since the provisions recommended here do not consider factors influencing the behaviour of non-structural elements. It is suggested that the major areas of improvement for the Indian seismic code could be along the following lines.

(*i*) Provisions of seismic relative displacement should be included for displacement sensitive elements that are attached to the structure at multiple points, for example, piping system, stairwells, cladding, etc.

(*ii*) It is necessary to define clearly the displacement sensitive and force sensitive elements.

(*iii*) Amplification of lateral force that increases with the increase of vertical location of the non-structural elements should be included for the design of the non-structural elements and their attachments.

(*iv*) Importance factor for various types of non-structural elements should be defined clearly.

(*v*) A parameter should be included to take care of flexibility of the non-structural elements.

(*vi*) A modification factor should be considered that represents ductility, redundancy, and energy dissipation capacity of the element and its attachment to the structures.

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