RESEARCH ARTICLE OPEN ACCESS

Design Drift Ratio As An Indicator Of Damage In Soft Storied RCC Buildings

M.P. Mishra[1], Dr.S.K.Dubey[2]
[1]Ph.D. Scholar MaulanaAzad National Institute of Technology, Bhopal (MP)
[2] ProfessorDept.of Structural Engineering, Maulana Azad National Institute of Technology, Bhopal (MP)
Corresponding Author: M.P. Mishra

ABSTRACT
Drift or distortion really governs the performance of a building in terms of damage both to the structural frame and to non-frame elements. In the year 1976, uniform building code (UBC) is probably the first code to set adrift limit. Drift in building frames is the result of flexural and shear mode contributions, due to columns axial deformations and to the diagonal and girder deformations. In low rise braced structures, the shear mode displacements are the most significant and will largely determine the lateral stiffness of the structure. In medium to high rise structures the higher axial forces and deformations in the columns, and the accumulation of their effects over a greater height cause flexural component of displacement to become dominant. The drift problem become more critical in soft storied RCC building particularly when kept open at Ground floor. Design storey drift ratio is the relative difference of design displacement between the top and bottom of a storey divided by the storey height. American concrete Institute (ACI) provides a limit that design storey drift ratio does not exceeds 0.005 to 0.03 to control the damages during severe earthquake.

Keywords-: Shear mode, Inter storey drift, Seismicdrift, soft storey, Lateralstiffness**.**

Date Of Submission:01-10-2018 Date Of Acceptance: 12-10-2018

I. INTRODUCTION

The primary functions of current seismic regulations for buildings structures are to provide minimum standards for design and to maintain public safety during the event of extreme earthquakes likely to occur at site of building. These regulations are intended primarily to safeguard against major failures and loss of life, not to damage, maintain functions, or provide for easy repair. The importance of drift control is revealed when it is accepted that the inter-storey drift ratio (difference in drift between two consecutive levels divided by storey height) constitutes an acceptable measure of distortion and of damage. Observations have confirmed that there is a good correlation between damage and the drift ratio. This limits demands a deformation capacity for the structural elements. If this deformation capacity can be attained by following a set of provisions that prescribe minimum details, then drift estimates alone would be sufficient to anticipate performance of buildings during earthquakes, without the need of information on ductility or on acceleration levels. It is seen that soft-storied buildings response is not 100% predictable according to the formulation or postulation made in different theories so a soft-storey building behavior during earthquake is not known, in what way it will get damage, tilt or collapse. Thus for a safety point of view of life and property we should try to utilize the full strength of material so that soft-storey behavior can be controlled causing less failure. Due to unpredictable behavior of soft-storey building in high seismic region such type of building has been banned particularly in developed countries not in India and Nepal etc. So our aim is to know the loading imposed by earthquake shaking under the building and its effects on structure. So design of the building will be on the basis that it should remain elastic or undergo inelastic behavior. For the special or critical buildings like nuclear power building design should be on the basis up to elastic range of properties, but for normal building it should be on the basis of inelastic behavior. So normal buildings are to be designed and develop favorable failure mechanism that possesses specified lateral strength, reasonable post yield deformability.

The drift problem is more critical in case of a soft storied RCC Buildings. Thus the displacement capacity of the soft storey building should be judged so that the nonstructural partitions attached can resist the deformation without losses and the content of the buildings are to be preserved during a strong earthquake. It is the nonstructural elements that control the selection of a tolerable drift limit. This limit depends on the economic risk of that society is willing to use.

As per IS 1893 (Part 1) : 2002 and 2016 states in clause 7.11.1 that the storey drift in any storey due to minimum specified design lateral force, with partial load factor 1.0 shall not exceed 0.004 times the storey height. The storey drift must be compared with the maximum permitted in the governing code. In Euro code 8 this is generally 1% of the storey height under the ultimate design earthquake, but up to twice the deflection is allowed where the cladding and partitions are not brittle, or are suitably isolated from the frame .IBC generally requires a limit of 1% of the storey height.

1.2 Design Storey drift Ratio (Φ)

It is the relative difference of design displacement between the top and bottom of a storey, divided by the storey height. American Concrete Institute (ACI) is an organization for developing and disseminating consensus based knowledge on concrete and its users. This has released a completely reorganized ACI-318-14. ACI-318-14 is one of the most essential and valuable standards with respect to design of concrete structures.

As per the clause 21.13.6 of ACI-318-14 states that, the design storey drift ratio does not exceed the larger of 0.005 and [0.035 - 0.05(Vug/ψVc)]. Where Vc is nominal shear strength provided by concrete, and Vug is the factored shear force on the slab critical section for two way action due to gravity loads. Signψ indicates a factor used to modify shear strength. As per the graph plotted between the Vug/ψVc and design storey drift ratio in the ACI-318-14, it is found that minimum value of design storey drift ratio is 0.005 whenVug/ψVc has a value 0.7. The maximum value of design storey drift ratio is 0.03 when Vug/ψVc has its value 0.1.Following Tables has been prepared showing design storey drift ratio obtained for different soft storied buildings which has different parameters mainly for column sizes and height of soft storey.

II. GEOMETRY AND DESCRIPTION OF MODEL

In the present work, A G+2 to G+20 RC frame building having typical floor height of 3.2m has been modelled with ETAB-2016.This studied building has five no bays in y-direction and 9 no bays in x-direction. The bay length in x-direction is 5m and in y-direction is 6m with a total plan area of 45m x30m. The total height of model for G+3,G+4, G+6, G+13, and G+20 is 9.9m, 16.3m, 22.70m, 45.1m and 67.5 respectively.M-25 Grade of concrete With Fe-415 grade of steel is being used for all types of modeling in this study and loading has considered as per IS-875-1987-Part-05 and part-2 and other calculationdetail as per IS-1983-2002and 2016-Part-1 with medium type of soil in zone-IV.

III. RESULT AND DISCUSSION

Above building configuration for G+2 TO G+20 has been modeled for the common model C1 to C41 which has general bare frame, and completely infilled frames and soft storey at different levels to know the real behaviour of the frames in different conditions. Again the result obtained for the above models has been analysed with keeping the soft storey at ground floor only but changing the height of soft storey and the columns sizes at soft storey level. The columns enlargement has done till the size to bring the design storey drift ratio to permissible limits. Below tables for models from C42 to C281 has been prepared which is reflecting the change in design storey drift ratio with respect to height of soft storey and different sizes of columns

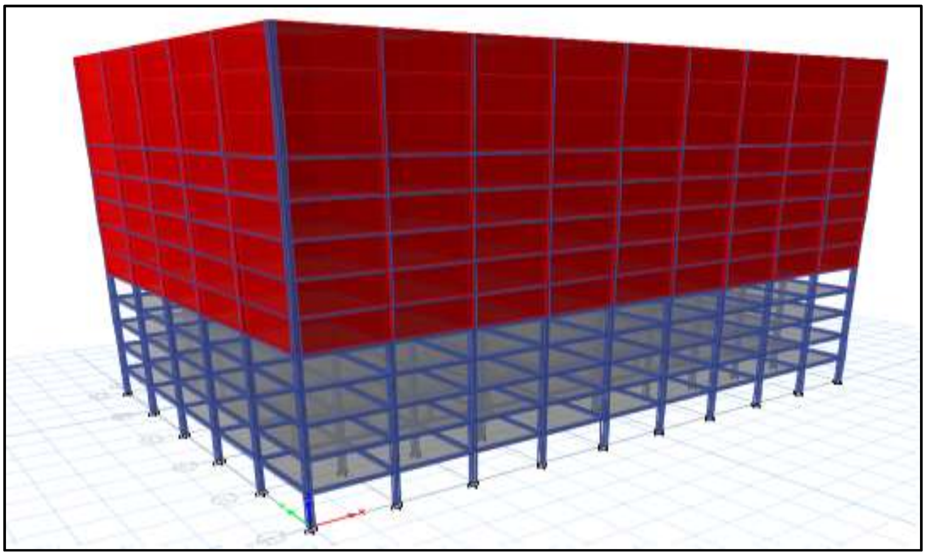

Figure.1 Rendered view of a 14-storey building having soft-storey up to 4 storey.

Table C.1: 3-Storey Column enhancement and change in Design storey drift ratio and drift For GF 3.50m -Models-C42 to C52

S.N.	Storey	Col. Size(mm)	δx(mm)	ΦX	δy(mm)	ΦY	Φ(0.005to 0.03)
1	Storey-1	300×300	10.11	0.0029	11.50	0.0033	<0.005
2	Storey-1	315×315	7.511	0.0021	8.146	0.0023	
3	Storey-1	330×330	6.25	0.0018	6.778	0.0019	
4	Storey-1	345×345	5.244	0.0015	5.688	0.0016	
5	Storey-1	360×360	4.434	0.0013	4.809	0.0014	
6	Storey-1	375×375	3.766	0.0011	4.095	0.0012	
7	Storey-1	390×390	3.236	0.0009	3.510	0.0010	
8	Storey-1	405×405	2.791	0.0008	3.027	0.0009	
9	Storey-1	420×420	2.420	0.0007	2.625	0.0008	
10	Storey-1	435×435	2.109	0.0006	2.288	0.0008	
11	Storey-1	450×450	1.847	0.0005	2.012	0.0006	

Table C.2: 3- Storey Column enhancement and change in Design storey drift ratio and drift For GF 4.00m-Models -C53 to C63

S.N.	Storey	Col. Size(mm)	δx(mm)	ΦX	δy(mm)	ΦY	Φ(0.005to0.03)
1	Storey-1	300×300	13.56	0.0033	14.711	0.0044	<0.005
2	Storey-1	315×315	11.182	0.0028	12.126	0.0030	
3	Storey-1	330×330	9.302	0.0023	10.088	.0025	
4	Storey-1	345×345	7.803	0.0019	8.462	0.0021	
5	Storey-1	360×360	6.596	0.0016	7.153	0.0018	
6	Storey-1	375×375	5.615	0.0014	6.090	0.0015	
7	Storey-1	390×390	4.811	0.0012	5.218	0.0013	
8	Storey-1	405×405	4.147	0.0010	4.498	0.0011	
9	Storey-1	420×420	3.595	0.0009	3.899	0.0009	
10	Storey-1	435×435	3.132	0.0008	3.398	0.0008	
11	Storey-1	450×450	2.743	0.0007	2.975	0.0007	

Table C.3: 3- Storey Column enhancement and change in Design storey drift ratio and drift ForGF 4.50 m- Models- C64 to C74

S.N.	Storey	Col. Size(mm)	δx(mm)	ΦX	δy(mm)	ΦY	Φ(0.005to 0.03)
1	Storey-1	300×300	19.288	0.0043	20.917	0.0046	<0.005
2	Storey-1	315×315	15.896	0.0034	17.239	0.0038	
3	Storey-1	330×330	13.222	0.0030	14.339	0.0032	
4	Storey-1	345×345	11.089	0.0025	12.027	0.0027	
5	Storey-1	360×360	9.373	0.0021	10.165	0.0023	
6	Storey-1	375×375	7.977	0.0018	8.652	0.0019	
7	Storey-1	390×390	6.834	0.0015	7.412	0.0016	
8	Storey-1	405×405	5.890	0.0013	6.388	0.0014	
9	Storey-1	420×420	5.105	0.0011	5.537	0.0012	
10	Storey-1	435×435	4.447	0.0009	4.824	0.0010	
11	Storey-1	450×450	3.893	0.0008	4.824	0.0009	

Table C.4: 3- Storey Column enhancement and change in Design storey drift ratio and drift For GF 5.00 m- Models- C75 to C85

S.N.	Storey	Col. Size(mm)	δx(mm)	ΦX	δy(mm)	ΦY	Φ(0.005to 0.03)
1	Storey-1	300×300	26.439	0.0052	28.672	0.0057	>0.005
2	Storey-1	315×315	21.788	0.0040	23.629	0.0047	<0.005
3	Storey-1	330×330	18.121	0.0036	19.965	0.0039	
4	Storey-1	345×345	15.198	0.0030	16.482	0.0032	
5	Storey-1	360×360	12.844	0.0025	13.929	0.0027	
6	Storey-1	375×375	10.931	0.0021	11.855	0.0023	
7	Storey-1	390×390	9.363	0.0018	10.155	0.0020	
8	Storey-1	405×405	8.069	0.0016	8.752	0.0017	
9	Storey-1	420×420	6.993	0.0013	7.584	0.0015	
10	Storey-1	435×435	6.091	0.0012	6.607	0.0013	
11	Storey-1	450×450	5.332	0.0010	5.783	0.0011	

Table C.5: 5- Storey Column enhancement and change in Design storey drift ratio and drift For GF 3.50 m- Models- C86 to C96

S.N.	Storey	Col. Size(mm)	δx(mm)	ΦX	δy(mm)	ΦY	Φ(0.005to 0.03)
1	Storey-1	300×300	16.528	0.0047	17.928	0.0051	>0.005
2	Storey-1	315×315	13.624	0.0039	14.778	0.0042	<0.005
3	Storey-1	330×330	11.333	0.0032	12.293	0.0035	
4	Storey-1	345×345	9.506	0.0027	10.313	0.0029	
5	Storey-1	360×360	8.036	0.0022	8.717	0.0025	
6	Storey-1	375×375	6.841	0.0019	7.421	0.0021	
7	Storey-1	390×390	5.861	0.0016	6.359	0.0018	
8	Storey-1	405×405	5.052	0.0014	5.481	0.0015	
9	Storey-1	420×420	4.379	0.0013	4.752	0.0014	
10	Storey-1	435×435	3.816	0.0011	4.140	0.0012	
11	Storey-1	450×450	3.341	0.0009	3.625	0.0010	

Table C.6: 5- Storey Column enhancement and change in Design storey drift ratio and drift For GF4.00 m- Models- C97 to C107

S.N.	Storey	Col. Size(mm)	δx(mm)	ΦX	δy(mm)	ΦY	Φ(0.005to 0.03)
1	Storey-1	300×300	24.60	0.0061	26.681	0.0067	>0.005
2	Storey-1	315×315	20.271	0.0051	21.987	0.0055	
3	Storey-1	330×330	16.855	0.0042	18.285	0.0046	<0.005
4	Storey-1	345×345	14.136	0.0035	15.334	0.0038	
5	Storey-1	360×360	11.945	0.0029	12.958	0.0032	
6	Storey-1	375×375	10.165	0.0025	11.027	0.0027	
7	Storey-1	390×390	8.706	0.0022	9.445	0.0024	
8	Storey-1	405×405	7.702	0.0019	8.139	0.0020	
9	Storey-1	420×420	6.50	0.0016	7.052	0.0018	
10	Storey-1	435×435	5.661	0.0014	6.143	0.0015	
11	Storey-1	450×450	4.955	0.0012	5.376	0.0013	

Table C.7: 5- Storey Column enhancement and change in Design storey drift ratio and drift For GF4.50 m- Models- C108 to C118

S.N.	Storey	Col. Size(mm)	δx(mm)	ΦX	δy(mm)	ΦY	Φ(0.005to 0.03)
1	Storey-1	300×300	34.961	0.0078	37.918	0.0084	>0.005
2	Storey-1	315×315	28.803	0.0064	31.241	0.0069	
3	Storey-1	330×330	23.948	0.0053	25.975	0.0057	
4	Storey-1	345×345	20.078	0.0044	21.778	0.0048	<0.005
5	Storey-1	360×360	16.962	0.0037	18.400	0.0040	
6	Storey-1	375×375	14.431	0.0032	15.656	0.0034	
7	Storey-1	390×390	12.358	0.0027	13.406	0.0029	
8	Storey-1	405×405	10.464	0.0023	11.549	0.0025	
9	Storey-1	420×420	9.222	0.0020	10.005	0.0022	
10	Storey-1	435×435	8.030	0.0018	8.712	0.0019	
11	Storey-1	450×450	7.026	0.0016	7.623	0.0017	

Table C.8: 5- Storey Column enhancement and change in Design storey drift ratio- and drift For GF5.00m Models- C119 to C129

S.N.	Storey	Col. Size(mm)	δx(mm)	ΦX	δy(mm)	ΦY	Φ(0.005to 0.03)
1	Storey-1	300×300	47.902	0.0095	51.952	0.0100	>0.005
2	Storey-1	315×315	39.46	0.0078	42.798	0.0085	
3	Storey-1	330×330	32.804	0.0065	35.58	0.0071	
4	Storey-1	345×345	27.499	0.0055	29.827	0.0060	
5	Storey-1	360×360	23.229	0.0046	25.196	0.0051	
6	Storey-1	375×375	19.76	0.0039	21.434	0.0043	<0.005
7	Storey-1	390×390	16.918	0.0033	18.352	0.0037	
8	Storey-1	405×405	14.572	0.0029	15.808	0.0031	
9	Storey-1	420×420	12.621	0.0025	13.692	0.0027	
10	Storey-1	435×435	10.988	0.0022	11.921	0.0024	
11	Storey-1	450×450	9.612	0.0019	10.429	0.0020	

Table C.9: 7- Storey Column enhancement and change in Design storey drift ratio and drift For GF3.50 m- Models- C130 to C140

S.N.	**Storey**	**Col. Size(mm)**	**δx(mm)**	**ΦX**	**δy(mm)**	**ΦY**	**Φ(0.005to 0.03)**
1	Storey-1	300×300	23.949	0.0068	26.312	0.0075	>0.005
2	Storey-1	315×315	19.739	0.0056	21.414	0.0061	
3	Storey-1	330×330	16.418	0.0047	17.813	0.0051	
4	Storey-1	345×345	13.771	0.0039	14.942	0.0042	<0.005
5	Storey-1	360×360	11.639	0.0033	12.63	0.0036	
6	Storey-1	375×375	9.907	0.0028	10.751	0.0030	
7	Storey-1	390×390	8.488	0.0024	9.211	0.0026	
8	Storey-1	405×405	7.315	0.0021	7.939	0.0022	
9	Storey-1	420×420	6.34	0.0018	6.881	0.0019	
10	Storey-1	435×435	5.524	0.0016	5.995	0.0017	
11	Storey-1	450×450	4.835	0.0014	5.249	0.0015	

Table C.10: 7- Storey Column enhancement and change in Design storey drift ratio and drift ForGF4.00 m- Models- C 141to C151

S.N.	**Storey**	**Col. Size(mm)**	**δx(mm)**	**ΦX**	**δy(mm)**	**ΦY**	**Φ (0.005to 0.03)**
1	Storey-1	300×300	35.638	0.0089	38.659	0.0096	>0.005
2	Storey-1	315×315	29.363	0.0073	31.854	0.0079	
3	Storey-1	330×330	24.416	0.0061	26.488	0.0066	
4	Storey-1	345×345	20.472	0.0051	22.21	0.0055	
5	Storey-1	360×360	17.297	0.0043	18.767	0.0047	<0.005
6	Storey-1	375×375	14.717	0.0037	15.969	0.0040	
7	Storey-1	390×390	12.603	0.0031	13.676	0.0034	
8	Storey-1	405×405	10.858	0.0027	11.783	0.0029	
9	Storey-1	420×420	9.407	0.0023	10.209	0.0025	
10	Storey-1	435×435	8.192	0.0020	8.891	0.0022	
11	Storey-1	450×450	7.168	0.0018	7.780	0.0019	

Table C.11: 7- Storey Column enhancement and change in Design storey drift ratio and drift For GF4.50 m- Models- C152 to C162

S.N.	**Storey**	**Col. Size(mm)**	**δx(mm)**	**ΦX**	**δy(mm)**	**ΦY**	**Φ(0.005to 0.03)**
1	Storey-1	300×300	50.639	0.0110	54.929	0.0120	>0.005
2	Storey-1	315×315	41.715	0.0090	45.25	0.0100	
3	Storey-1	330×330	34.678	0.0076	37.619	0.0083	
4	Storey-1	345×345	29.07	0.0064	31.537	0.0070	
5	Storey-1	360×360	24.556	0.0055	26.641	0.0059	
6	Storey-1	375×375	20.888	0.0046	22.663	0.0051	
7	Storey-1	390×390	17.884	0.0039	19.404	0.0043	<0.005
8	Storey-1	405×405	15.404	0.0034	16.714	0.0037	
9	Storey-1	420×420	13.341	0.0029	14.477	0.0032	
10	Storey-1	435×435	11.615	0.0026	12.604	0.0028	
11	Storey-1	450×450	10.16	0.0022	11.027	0.0024	

Table C.12: 7- Storey Column enhancement and change in Design storey drift ratio- and drift For GF5.00 m-Models- C163 to C173

S.N.	Storey	Col. Size(mm)	δx(mm)	ΦX	δy(mm)	ΦY	Φ(0.005to 0.03)
1	Storey-1	300×300	69.37	0.0138	75.243	0.0150	>0.005
2	Storey-1	315×315	57.136	0.0114	61.977	0.0123	
3	Storey-1	330×330	47.492	0.0094	51.517	0.0103	
4	Storey-1	345×345	39.805	0.0079	43.185	0.0086	
5	Storey-1	360×360	33.619	0.0067	36.471	0.0073	
6	Storey-1	375×375	28.593	0.0057	31.021	0.0062	
7	Storey-1	390×390	24.476	0.0049	26.556	0.0053	
8	Storey-1	405×405	21.078	0.0042	22.87	0.0046	<0.005
9	Storey-1	420×420	18.252	0.0036	19.805	0.0039	
10	Storey-1	435×435	15.887	0.0032	17.24	0.0034	
11	Storey-1	450×450	13.895	0.0027	15.079	0.0030	

Table C.13: 14- Storey Column enhancement and change in Design storey drift ratio and drift For GF3.50 m- Models- C174 to C184

S.N.	Storey	Col. Size(mm)	δx(mm)	ΦX	δy(mm)	ΦY	Φ(0.005to 0.03)
1	Storey-1	300×300	46.23	0.0132	50.175	0.0143	>0.005
2	Storey-1	315×315	38.1	0.0108	41.355	0.0118	
3	Storey-1	330×330	31.689	0.0090	34.40	0.0098	
4	Storey-1	345×345	26.577	0.0076	28.854	0.0082	
5	Storey-1	360×360	22.462	0.0064	24.389	0.0069	
6	Storey-1	375×375	19.118	0.0054	20.76	0.0059	
7	Storey-1	390×390	16.377	0.0047	17.786	0.0051	
8	Storey-1	405×405	14.114	0.0040	15.33	0.0044	<0.005
9	Storey-1	420×420	12.231	0.0035	13.287	0.0038	
10	Storey-1	435×435	10.655	0.0030	11.577	0.0033	
11	Storey-1	450×450	9.327	0.0026	10.135	0.0028	

Table C.14: 14- Storey Column enhancement and change in Design storey drift ratio and drift For GF4.00 m- Models- C 185to C195

S.N.	Storey	Col. Size(mm)	δx(mm)	ΦX	δy(mm)	ΦY	Φ (0.005to 0.03)
1	Storey-1	300×300	68.755	0.0171	74.635	0.0186	>0.005
2	Storey-1	315×315	56.661	0.0141	61.495	0.0153	
3	Storey-1	330×330	47.11	0.0117	51.133	0.0127	
4	Storey-1	345×345	39.497	0.0098	42.874	0.0107	
5	Storey-1	360×360	33.367	0.0083	36.224	0.0090	
6	Storey-1	375×375	28.388	0.0070	30.822	0.0077	
7	Storey-1	390×390	24.308	0.0060	26.395	0.0065	
8	Storey-1	405×405	20.94	0.0052	22.74	0.0057	
9	Storey-1	420×420	18.139	0.0045	19.701	0.0049	<0.005
10	Storey-1	435×435	15.794	0.0039	17.156	0.0043	
11	Storey-1	450×450	13.819	0.0034	15.013	0.0037	

Table C.15: 14- Storey Column enhancement and change in Design storey drift ratio and drift For GF4.50 m- Models- C196to C207

S.N.	**Storey**	**Col. Size(mm)**	**δx(mm)**	**ΦX**	**δy(mm)**	**ΦY**	**Φ(0.005to 0.03)**
1	Storey-1	300×300	97.702	0.0217	106.017	0.0235	>0.005
2	Storey-1	315×315	89.474	0.0198	87.33	0.0193	
3	Storey-1	330×330	66.892	0.0148	72.597	0.0161	
4	Storey-1	345×345	56.068	0.0124	60.855	0.0135	
5	Storey-1	360×360	47.355	0.0105	51.403	0.0114	
6	Storey-1	375×375	40.277	0.0089	43.724	0.0097	
7	Storey-1	405×405	29.693	0.0065	32.241	0.0071	
8	Storey-1	420×420	25.713	0.0057	27.922	0.0061	
9	Storey-1	450×450	19.577	0.0043	21.263	0.0047	<0.005
10	Storey-1	480×480	15.95	0.0035	17.99	0.0039	
11	Storey-1	495×495	13.77	0.0030	15.80	0.0035	

Table C.16: 14- Storey Column enhancement and change in Design storey drift ratio- and drift For GF5.00 m- Models- C208 to C221

S.N	**Storey**	**Col. Size(mm)**	**δx(mm)**	**ΦX**	**δy(mm)**	**ΦY**	**Φ(0.005to 0.03)**
1	Storey-1	300×300	133.809	0.0267	145.187	0.0290	>0.005
2	Storey-1	315×315	110.197	0.0220	119.576	0.0239	
3	Storey-1	330×330	91.584	0.0183	99.386	0.0198	
4	Storey-1	345×345	76.75	0.0153	83.295	0.0166	
5	Storey-1	360×360	64.811	0.0129	70.344	0.0140	
6	Storey-1	375×375	55.114	0.0110	59,824	0.0119	
7	Storey-1	405×405	40.615	0.0093	44.093	0.0088	
8	Storey-1	420×420	35.164	0.0070	38.179	0.0076	
9	Storey-1	450×450	26.76	0.0053	29.061	0.0058	
10	Storey-1	480×480	20.735	0.0041	22.522	0.0045	<0.005
11	Storey-1	495×495	18.363	0.0036	19.948	0.0039	

Table C.17: 21- Storey Column enhancement and change in Design storey drift ratio and drift For GF3.50 m- Models- C222 to C235

S.N.	**Storey**	**Col. Size(mm)**	**δx(mm)**	**ΦX**	**δy(mm)**	**ΦY**	**Φ (0.005to 0.03)**
1	Storey-1	300×300	72.256	0.0206	78.465	0.0224	>0.005
2	Storey-1	315×315	59.551	0.0170	64.678	0.0185	
3	Storey-1	330×330	49.531	0.0141	53.804	0.0153	
4	Storey-1	345×345	41.543	0.0118	45.134	0.0128	
5	Storey-1	360×360	35.111	0.0100	38.154	0.0109	
6	Storey-1	375×375	29.884	0.0085	32.479	0.0092	
7	Storey-1	405×405	22.063	0.0063	23.989	0.0068	
8	Storey-1	420×420	19.121	0.0054	20.794	0.0059	
9	Storey-1	450×450	14.582	0.0041	15.864	0.0045	<0.005
10	Storey-1	480×480	11.323	0.0032	12.324	0.0035	
11	Storey-1	495×495	10.04	0.0028	10.93	0.0031	

Table C.18: 21- Storey Column enhancement and change in Design storey drift ratio and drift For GF4.00 m- Models- C 236to C249

S.N.	**Storey**	**Col. Size(mm)**	**δx(mm)**	**ΦX**	**δy(mm)**	**ΦY**	**Φ (0.005to 0.03)**
1	Storey-1	300×300	107.478	0.0268	116.691	0.0291	>0.005
2	Storey-1	315×315	88.547	0.0221	96.151	0.0240	
3	Storey-1	330×330	73.621	0.0184	79.955	0.0199	
4	Storey-1	345×345	61.724	0.0154	67.044	0.0167	
5	Storey-1	360×360	52.146	0.0130	56.65	0.0141	
6	Storey-1	375×375	44.365	0.0110	48.204	0.0120	
7	Storey-1	405×405	32.726	0.0081	35.57	0.0088	
8	Storey-1	450×450	21.597	0.0053	23.487	0.0058	
9	Storey-1	480×480	16.754	0.0041	18.227	0.0045	<0.005
10	Storey-1	495×495	14.846	0.0037	16.155	0.0040	
11	Storey-1	510×510	13.550	0.0033	14.995	0.0037	

Table C.19: 21- Storey Column enhancement and change in Design storey drift ratio and drift For GF4.50 m- Models- C250to C264

S.N.	**Storey**	**Col. Size(mm)**	**δx(mm)**	**ΦX**	**δy(mm)**	**ΦY**	**Φ(0.005to 0.03)**
1	Storey-1	300×300	152.661	0.0339	165.725	0.0368	>0.03
2	Storey-1	315×315	125.742	0.0279	136.519	0.0303	
3	Storey-1	330×330	104.52	0.0261	113.492	0.0252	
4	Storey-1	345×345	87.606	0.0194	95.139	0.0211	
5	Storey-1	360×360	73.991	0.0164	80.365	0.0178	
6	Storey-1	375×375	62.932	0.0139	68.363	0.0152	
7	Storey-1	405×405	46.394	0.0103	50.413	0.0112	
8	Storey-1	420×420	40.175	0.0089	43.663	0.0097	
9	Storey-1	450×450	30.587	0.0067	33.253	0.0073	
10	Storey-1	510×510	18.674	0.0041	20.317	0.0045	<0.005
11	Storey-1	525×525	16.230	0.0036	17.845	0.0039	

Table C.20: 21- Storey Column enhancement and change in Design storey drift ratio- and drift For GF5.00 m- Models- C265 to C281

S.N.	**Storey**	**Col. Size(mm)**	**δx(mm)**	**ΦX**	**δy(mm)**	**ΦY**	**Φ(0.005to 0.03)**
1	Storey-1	300×300	209.055	0.0418	226.981	0.0453	>0.03
2	Storey-1	315×315	172.162	0.0344	186.894	0.0373	
3	Storey-1	330×330	143.079	0.0286	155.34	0.0310	
4	Storey-1	345×345	119.903	0.0239	130.194	0.2603	
5	Storey-1	360×360	101.249	0.0202	109.953	0.0219	
6	Storey-1	375×375	86.098	0.0172	93.511	0.0187	
7	Storey-1	420×420	54.928	0.0109	59.683	0.0119	
8	Storey-1	450×450	41.798	0.0083	45.430	0.0090	
9	Storey-1	480×480	32.385	0.0064	35.211	0.0070	
10	Storey-1	525×525	22.739	0.0048	24.736	0.0051	
11	Storey-1	540×540	20.351	0.0040	22.142	0.0044	<0.005
12	Storey-1	555×555	18.870	0.0037	19.770	0.0039	

Table C.21:3 to 21 storey- Value of safe Design Storey Drift Ratio Φ for different soft storey heights and different No of storey Buildings

SN	No of Storey	Φ for3.50m	Φfor4.00m	Φfor4.50m	Φfor5.00m	Remark
1	3-Storey Column Size	0.0028 300×300	0.0036 300×300	0.0046 300×300	0.0057 315×315	Permissible inter Storey drift ratio 0.005to 0.03
2	5-Storey Column Size	0.0042 315×315	0.0045 330×330	0.0048 345×345	0.0042 375×375	
3	7-Storey Column Size	0.0042 345×345	0.0046 360×60	0.0043 390×390	0.0045 405×405	
4	14-Storey Column Size	0.0044 390×390	0.0045 405×405	0.0047 450×450	0.0045 480×480	
5	21-Storey Column Size	0.0050 435×435	0.0050 465×465	0.0045 510×510	0.0049 525×540	Maximum value of Φ is 0.0453 for 21-Storey for 5m base storey column300×300

3.1 TableC.1**:3to**TableC.3:3shows that maximum limit of design storey drift ratio is below to minimum limit 0.005. Tables C.4:3 to Table C.18:21 shows that maximum design storey drift ratio is crossing the minimum limit 0.005 for some column sections but not the maximum limit 0.03 beyond this nonstructural members including cladding can have distortion and they will loosen their utility.

3.2 Table C.19:21 shows that for column section 300 mm×300 mm to 495 mm × 495 mm design storey drift limit is crossing the maximum limit 0.03 and it is coming in control at column section 510 mm×510 mm.Similarly Table C.20:21 showing that at column section 540 mm × 540 mm design storey drift ratio is within the maximum limit.

3.3Table C.20:21 fortwenty one storeys having ground soft storey height 5.00 m is critical for the column sections 300 mm×300 mm to 540 mm × 540 mm. maximum design storey drift ratio is 9.06 times to minimum Φ and 1.51 times to maximum limit Φ.

3.4 Table C.21:3 to 21 storey- In this Table Value of safe Design Storey Drift Ratio Φ for different soft storied building has been mentioned, which gives the idea at what column section building will have safe design storey drift ratio. Hence on the basis of above concept any soft storey building will give the information about the safe column section needed tokeep Design Storey Drift Ratio Φ within the safe limit 0.005 to 0.03.

IV. CONCLUSIONS

Hence from the above results obtained during analysis, itis seen that there is a good correlation between damage and the drift ratio. To safeguard the soft first storey from damage and collapse,clause 7.10 of IS 1893 (Part1): 2002 and 2016 provides two alternative design approaches. First way is to do dynamic analysis of the building which should include the strength and stiffness effects of infills as well as the inelastic deformationsunder the design earthquake force disregarding the Reduction Factor R. Second way is thata building can be analysed as a bare frame neglecting the effect ofinfills and, the dynamic forces so determined in columns and beams of the soft (stilt) storey are to be designed for 2.5 times the storey shears and moments OR the shear walls are introduced in the stilt storey in both directions of the building which should be designed for 1.5 times the calculated storey shear forces.

The combined result obtained for the different models has been analyzed and found that soft storey height should be within 3 to 3.5m to have a good command on drift by simply enlarging the size of column without the provisions of other safety measures up to 21 storied building. It is also found that shear wall is most suitable and economical nearby fifteen storied building.

Thus a designer should initially check the design storey drift ratio within limit to have safe designconsidering others factor also like economy and safety.

REFERENCES

[1]. Murty CVR. And Jain SK "A review of IS-1893-1984 Provisions on seismic designs of building "The Indian concrete journal, November 1994.

[2]. Agarwal, Pankaj., and Shrikhande, Manish., "Earthquake resistant design of structure." PHI, Learning Pvt. Ltd. New Delhi-2010.

[3]. 3.Study material of short course on seismic design of high rise building-Indian Institute of information technology Hyderabad 4.Bayrak, Oguzhan., and Shamim, A. Sheikh., 2001, "Plastic

Hinge Analysis." Journal of Structural Engineering , 1092-1100.

[4]. Bento, Rita., and Jojo, Azevedo., 2000, "Behavior Coefficient Assessment for Soft-Storey Structures." 12th WCCEE-2000, Instituto Superior Tecnico-Lisbon.

[5]. IS 1893 (Part I)., 2002 and 2016, "Indian Standards criteria for Earthquake Resistant Design of Structures. Part 1- General Provisions and Buildings (Fifth Revision)."Bureau of Indian Standards, New Delhi.

[6]. Teresa, Guevara., and Perez, L., 2012 , "Soft storey and weak storey in earthquake resistant design: A multidisciplinary Approach."15th World congress of earthquake engineering, LISBOA.

[7]. Wallace, J.W., and Moehle, J.P., 1992, "Ductility and detailing requirements of bearing wall buildings."Journal of Structural Engineering,American Society of Civil Engineers 9(6),1625-1644.

[8]. Nelson, Lam., John, Wilson., and Kittipoom, Rodsin., 2008, "Collapse Modeling of Soft-Storey Buildings. Australian Journal of Structural Engineering."Inst. of Engrs Australia, 5 (1), 17-27

[9]. Manabu ,Yoshimura., 1999, "Control of Seismic Drift Demand for Reinforced Concrete Buildings with Weak First Stories." Department of Architecture, Tokyo Metropolitan University, Minamiosawa 1-1, Hachioji, Tokyo, 192-03, Japan.

[10]. Aainawala, M.S., and Pajgade, P.S., 2013, "Design of Multistoried R.C.C. Buildings with and without Shear Walls."International Journal of Engineering sciences & Research Technology, 3(7) , 2277-9655.

M.P. Mishra "Design Drift Ratio As An Indicator Of Damage In Soft Storied RCC Buildings 'International Journal of Engineering Research and Applications (IJERA) , vol. 8, no.10, 2018, pp 12-22