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COMPARATIVE DESIGN OF 10-STORY REINFORCED CONCRETE BUILDING USING UBC 1982, ATC-3-06 AND JAPANESE BUILDING CODE

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SUMMARY

As every country has its own seismic design code and so that the provisions might be different in the way that the analysis and design are performed, a comparison using only the seismic force is not so realistic.

A reinforced concrete building has been designed using the U.S. and Japanese codes, in order to understand clearly the differences between both countries structural design methods for reinforced concrete buildings.

INTRODUCTION

The building is a 10-story reinforced concrete office building located in San Jose, which has originally designed in accordance with the provisions of the 1964 Uniform Building Code(UBC), and was designed in accordance with the provisions of UBC 1982 and ATC-3-06. The same building has been redesigned based on current Japanese codes, assuming that it is located in Tokyo.

Outline of building

- Usage ------------------ Office Building
- Location ---------------- San Jose, U.S.A.
  Tokyo, Japan
- Number of Stories ------- 10 + Basement 1
- Floor Area ------------- 1,447.8 m^2 (15,580 ft^2)
- Total Floor Area -------- 14,447.5 m^2 (155,800 ft^2)
- Floor to Floor Height --- 4.88 m (16') for 1st floor
  3.66 m (12') for typical floor
- Total Height ------------ 37.82 m (124')
- Bay Size ---------------- 8.23 m x 9.3 m (27' x 30'6")
- Plan Dimentions --------- 57.91 m x 25.0 m (190' x 82')

Figure 1 shows typical floor framing plan by ATC-3(upper) and JPN code(lower).
Figure 2 shows transverse frame elevation by ATC-3(upper) and JPN code(lower).
Figure 3 shows interior colomn elevation by ATC-3(upper) and JPN code(lower).
Figure 4 shows exterior column elevation by ATC-3(upper) and JPN code(lower).

Structural concept Resistance to lateral forces in the transverse direction is provided by non-load-bearing reinforced concrete shear walls at each end of the building. These elements are supplemented by six rows of transverse framing that support vertical loads and offer nominal resistance to lateral loads.
In the longitudiral direction, lateral-load resistance is provided by two interior and two exterior frames.

COMPARISON OF DESIGN

Comparative items	U.S. code ATC-3-06	U.S. code UBC 1982	Japanese code
1. Analysis procedure			
1) Building height	H=37.82m $<$ 72m	H=37.82 $<$ 72m	H=37.82m $<$ 45m $>$ 31m
2) Building configulation	Regular	Regular	Fes=1.0
3) Analysis procedure	Equivalent lateral force procedure	Equivalent lateral force procedure	Equivalent lateral force procedure
2. Design seismic force			
1) Ground motion	Map area=7 (San Jose) Av=0.4	Seismic zone=4 (San Jose) Z=1.0	Z=1.0
2) Importance factor	Seismic index=4 Seismic hazard exposure group=II Seismic performance category=c	I=1.0	I=1.0
3) Framing system	Seismic-resisting frame X Dual System, Moment frame w/shear wall + ductile moment resisting frame Y Moment Resisting Frame System, Ductile moment resisting frame	Seismic-resisting frame X Dual System, Moment frame w/shear wall + moment frame Y Moment frame	Seismic frame (All frame) X Moment frame w/shear wall + Moment frame Y Moment frame
4) Ductility factor	X R=8 Cd=6.5 Y R=7 Cd=6	X K=0.8 Y K=0.67	X Ds=0.40 Y Ds=0.30

Comparative items	U.S. code ATC-3-06	U.S. code UBC 1982	Japanese code
5) Natural period	X $T=\frac{0.05hn}{\sqrt{L}}$ =0.69 sec. from computer analysis T=0.44 sec. Y $T=C_T hn^{3/4}$ =0.93 sec. from computer analysis T=0.71 sec.	X $T=\frac{0.05hn}{\sqrt{D}}$ =0.685 sec. from computer analysis T=0.44 sec. Y T=0.1N =1.0 sec. from computer analysis T=0.71 sec.	T=0.02H =0.76 sec.
6) Co-efficient for base shear	---	$C=\frac{1}{15\sqrt{T}}$ X C=0.101 Y C=0.079	---
7) Soil effect	S=1.2 Soil profile type:S2	S=1.5	$Rt=1-0.2(\frac{T}{Tc}-1)^2$ =0.985 Soil profile type:2 Tc=0.6 sec.
8) Building weight	W=11,113t	W=11,113t	W=18,233t
9) 1st-step design base shear	Limit level V=Cs.W $Cs=\frac{1.2Av.S}{R.T^{2/3}}$ X Cs=0.124 V=1,378t Y Cs=0.103 V=1,145t	Allowable level V=Z.I.K.C.S.W X C.S max=0.14 V=0.112.W =1,245t Y C=0.079 V=0.0794W =882t	Allowable level Q=Z.Rt.Ai.Co.W Co=0.2 X.Y Q=0.197.W =3,140t
10) 2nd-step design base shear	---	---	Qun=Ds.Fes.Qud Qud=Z.Rt.Ai.Co.W Co=1.0 X Qun=0.394.W =7,184t Y Qun=0.2955.W =5,388t
11) Level of design lateral force	$Qun=\frac{1.0}{0.9}V$ X Qun=0.138.W =1,531t Y Qun=0.144.W =1,272t	$Qun=\frac{1.4}{0.9}V$ X Qun=0.174.W =1,937t Y Qun=0.125.W =1,372t	

Comparative items	U.S. code ATC-3-06	U.S. code UBC 1982	Japanese code
12) Vertical distribution	Inverted triangular distribution $Fx = Cvx.V$ $Cvx = \frac{W_x \cdot h_x}{\sum_{i=1}^{n} W_i \cdot h_i}$	Concentrated at the top & invested triangular distribution $Fx = \frac{(V - F_t) W_x \cdot h_x}{\sum_{i=1}^{n} W_i \cdot h_i}$ Ft= 0.07T.V<0.25V (T > 0.7) Ft=0 (T ≤ 0.7) X Ft=0 Y Ft=0.050.V =44t	Ai - distribution $\alpha_i = \frac{\sum_{i=i}^{n} W_i}{\sum_{i=1}^{n} W_i}$ $Ai = 1 + (\frac{1}{\sqrt{\alpha_i}} - \sqrt{\alpha_i}) \frac{2T}{1+3T}$ 10F Ai = 2.52 9F 2.04 8F 1.80 7F 1.63 6F 1.50 5F 1.40 4F 1.30 3F 1.20 2F 1.10 1F 1.00
3. Horizontal distribution	X Ext. frame (Ductile moment resisting frame with shear wall) 95% Int. frame 25% Y Ext. frame Int. frame	X Ext. frame (Ductile moment resisting frame with shear wall) 100% Int. frame 25% Y Ext. frame Int. frame	X Ext. frame (Frame with shear wall) 60% Int. frame 40% Y Ext. frame 50% Int. frame 50%
4. Horizontal torsion	Calculated plus 5% accidental	Calculated plus 5% accidental	Calculated only
5. Orthogonal effects	30% to be considered by the reason of seismic performance category C.	Not considered	Not considered
6. Member section (cm)			
1) Girder(X)	BxD=30x59(8F) BxD=30x90(2F)	BxD=30x59(8F) BxD=30x90(2F)	BxD=50x120(8F) BxD=65x130(2F)
2) Girder(Y) int.	BxD=65x60(all)	BxD=65x60(all)	BxD=40X120(8F) BxD=55x130(2F)
ext.	BxD=45x120 BxD=45x150(2F)	BxD=45x120 BxD=45x150(2F)	BxD=40X120(8F) BxD=55x130(2F)

Comparative items	U.S. code ATC-3-06	U.S. code UBC 1982	Japanese code
3) Column			
int.	BxD=60x90(all)	BxD=60x90(all)	BxD=100x100(7F) BxD=120x120(1F)
ext.	BxD=45x180(all)	BxD=45x180(all)	BxD=100x100(7F) BxD=120x120(1F)
4) Wall	t=30	t=30	t=20

CONCLUDING REMARKS

1. The ATC-3-06 provisions generate higher seismic force levels than the 1982 UBC provisions and require the use (in some cases) of substantially lower capacity reduction factors. But, as well as requiring consideration of orthogral effects, essentially similar design were produced.

2. In large part, these factors are offset by the use of smaller load factors in the ATC-3-06 provisions when combining load factors. Whereas the 1982 UBC requires a 1.4 factor times dead, live, and seismic effects(2.0 for seismic effects on shear walls), ATC-3-06 requires a 1.2 factor for dead load effects and 1.0 factor for seismic and live load effects.

3. The Japanese codes produced a base shear coefficient of 0.185, the UBC and ATC-3 produced values that ranged from 0.079 to 0.124. The Japanese codes do not increase their design forces by the use of load and capacity reduction factors. If the UBC base shear coefficient in the transverse direction is multiplied by 1.4/0.9(load factor/flexural capacity reduction factor) an effective base shear coeficient of 0.174 results. But the Japanese codes produced a base shear coefficient of 0.394 in 2nd-step design.

4. For the subject structure, it appears that the Japanese codes require redesign for higher force levels than US code. This and their procedures for preliminary member sizing produce significantly larger members which in turn would make this type of a structural system uneconomical in Japan.

REFERENCES

1. ATC-3-06
2. UBC 1982
3. New assismic design method in Japan
4. ATC-3-4 Redesign of three multistory buildings: A comparison using ATC-3-06 and 1982 Uniform Building Code Design Provisions
5. ATC-15-1 Proceedings of second U.S.-Japan workshop on improvement of seismic design and construction practices

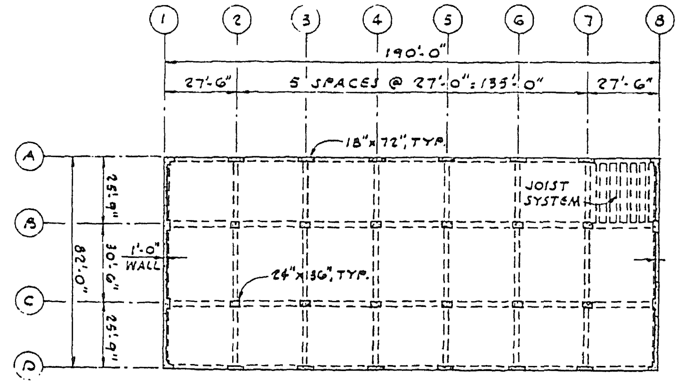


Figure 1 typical floor framing plan by ATC-3

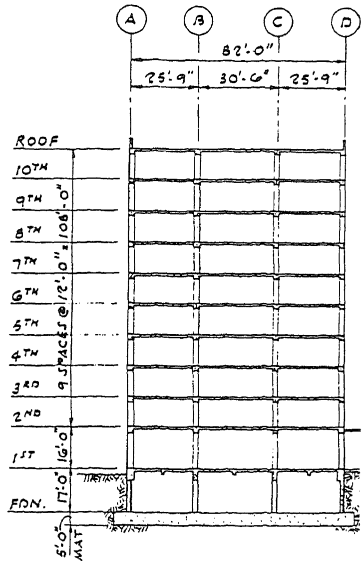


Figure 2 transverse frame elevation by ATC-3

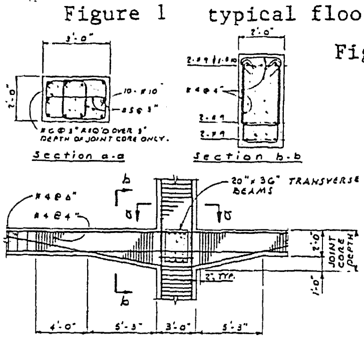


Figure 3 interior colomn elevation by ATC-3

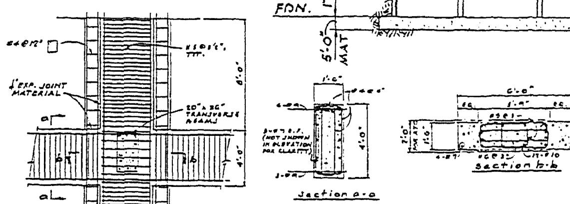


Figure 4 exterior column elevation by ATC-3

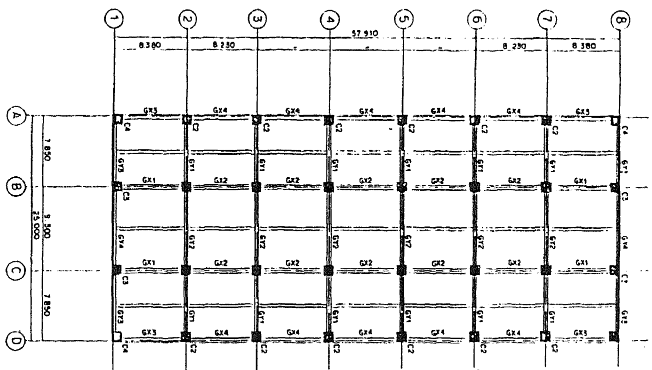
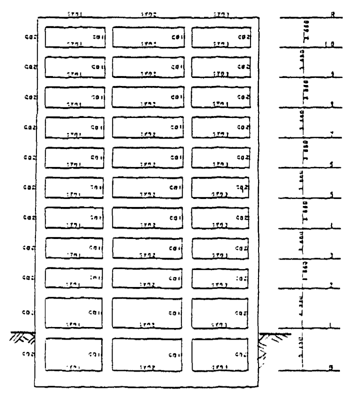


Figure 1 typical floor framing plan by JPN code



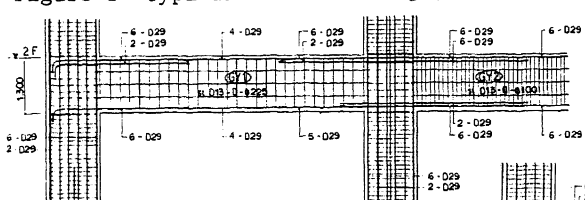
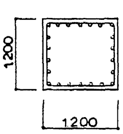


Figure 2 transverse frame elevation by JPN code



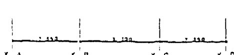
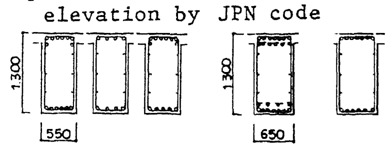


Figure 3 interior colomn elevation by JPN code



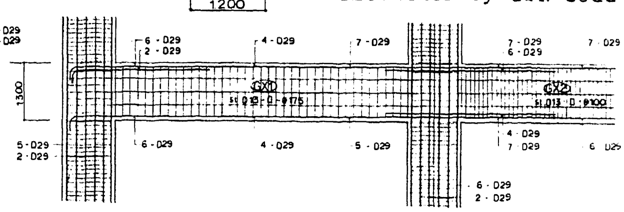


Figure 4 exterior column elevation by JPN code