How Important Are the New Factors in the Recent Earthquake Code for Concrete Structures

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SUMMARY:
After the 1906 San Francisco earthquake, the only lateral force requirement placed on structures in San Francisco was 30 lb/ft2 wind loading. In 1933 just 2% (CS = 0.02) of the dead load for all buildings was considered as base shear (V=CS.W), and 10% (CS = 0.1) for masonry school buildings. Between 1943 and 1953, the base shear coefficient was modified several times based on the building period and/or the height of a building. In the recent IBC 2006 the base shear equation is almost the same as the 1991 UBC, but the coefficients quantities have changed. The recent code will provide the lateral earthquake load at strength level, so in ASD (allowable stress design) method a load factor equal to 0.7 will be used for this lateral force. In 1991 UBC the lateral earthquake load was at allowable strength level, so in ASD method no load factor will be used for the earthquake load. In this paper three different reinforced concrete structures with Ordinary moment frame reinforced concrete, ordinary shear wall reinforced concrete, and special shear wall reinforced concrete with three different 6m, 30m, and 45m heights will be considered and base shear forces based on UBC1991 and IBC2006 are calculated and the results are shown in charts for comparison.

Keywords: Response modification coefficient, equivalent Static Analysis, strength and allowable strength level.

1. BASE SHEAR

1991 UBC determined the seismic base shear coefficient as Eqn. 1.1.

$$C_S = (Z.I.C)/R \qquad \text{and} \qquad C = (1.25S)/(T^{2/3}) \leq 2.75 \tag{1.1}$$

2006 IBC modified the base shear coefficient as Eqn. 1.2.

$$0.01 \leq C_S = (SDS)/(R/I) \quad \begin{cases} \leq (SD1)/[T(R/I)] & \text{for } T \leq TL \\ \leq (SD1.\ TL)/[T^2(R/I)] & \text{for } T > TL \end{cases} \tag{1.2}$$

As it can be seen few new coefficients are added to the old version. Adding these new parameters is made using and finding the base shear coefficient harder and more time consuming for designers to pick up the right quantity for the parameters. In addition some parameters shall be determined from the 0.2 and 1-second spectral response accelerations map that are shown on Figures 1613.5(1) through 1613.5(14) in 2006 IBC.

1.1 Minimum design base shear per UBC 1991

Base shear and fundamental period of vibration will be calculated from Eqns. 1.3 and 1.4 respectively.

$$V = C_S.W \tag{1.3}$$

$$T = Ct(hn)^{3/4} \tag{1.4}$$

C_S will be calculated per Eqn.1.1 and Ct is shown in Table 1.1 and hn is the height of the structure from the base.
Z = seismic zone factor given in Table 1.2.
S =Site coefficient given in Table 1.3.
I = Importance Factor, and in this paper it is considered one.

Table 1.1. Ct and R parameters for different system under consideration

System	Ct	R
OMFRC	0.03	5
OSWRC	0.02	8
SSWRC	0.02	12

OMFRC = Ordinary moment frame reinforced concrete
OSWRC = Ordinary shear wall reinforced concrete
SSWRC = Special shear wall reinforced concrete
Z = seismic zone factor given in Table 1.2.

Table 1.2. Z parameter for different zones

Zone	1	2A	2B	3	4
Z	0.075	0.15	0.20	0.30	0.40

Table 1.3. Site Coefficients

Description	S
Hard Rock and Rock	1
Very Dense Soil	1.2
Stiff Soil	1.5
Soft Clay	2

1.2 Minimum design base shear per IBC 2006

In order to calculate minimum lateral load per IBC 2006 the following information related to seismic loads regardless of whether seismic loads govern the design of the lateral-force-resisting system of the building must be determined:
1. Seismic importance factor, *I,* based on occupancy category. In this paper "I" will be considered one.
2. Mapped spectral response accelerations, Ss and S_1, that must be obtained from Figures 1613.5(1) through 1613.5(14) in IBC 2006, for the United States of America.
3. Site class. Based on IBC 2006 there are six site classes (A to F).
4. Design spectral response coefficients, S_{DS} and S_{DI}.
5. Seismic design category.
6. Basic seismic-force-resisting system(s).
7. Design base shear.
8. Seismic response coefficient(s), *C.*
9. Response modification factor(s), *R.*

Base shear and fundamental period of vibration will be calculated from Eqns. 1.5 and 1.6 respectively.

$$V = Cs.W \tag{1.5}$$
$$T = Ct(hn)^x \tag{1.6}$$

Cs will be calculated per Eqn. 1.2, and for that matter we need to find S1 and Ss from the maps provided in IBC 2006. Ct and R are shown in Table 1.4.

Table 1.4. Ct and R parameters for different system under consideration

System	Ct	R	X
OMFRC	0.028	3	0.9
OSWRC	0.02	5	0.75
SSWRC	0.02	6	0.75

TL = Long-period transition period (s) that must be picked from the maps in IBC 2006 for USA.
S_S = the mapped MCE spectral response acceleration at short periods as determined in accordance.
S_1 = the mapped MCE spectral response acceleration at a period of 1 sec Site coefficients *Fa* and *Fv* are shown in Tables 1.5 and 1.6 respectively.

Table 1.5. Site Coefficient, Fa

Site Class	Mapped Maximum Considered Earthquake Spectral Response Acceleration Parameter at Short Period				
	$S_S \le 0.25$	$S_S = 0.5$	$S_S = 0.75$	$S_S = 1.0$	$S_S \ge 1.25$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.2	1.2	1.1	1.0	1.0
D	1.6	1.4	1.2	1.1	1.0
E	2.5	1.7	1.2	0.9	0.9
F	See Section 11.4.7				

Table 1.6. Site Coefficient, Fv

Site Class	Mapped Maximum Considered Earthquake Spectral Response Acceleration Parameter at 1-s Period				
	$S_1 \le 0.1$	$S_1 = 0.2$	$S_1 = 0.3$	$S_1 = 0.4$	$S_1 \ge 0.5$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.7	1.6	1.5	1.4	1.3
D	2.4	2.0	1.8	1.6	1.5
E	3.5	3.2	2.8	2.4	2.4
F	See Section 11.4.7				

The MCE spectral response acceleration for short periods (*SMS*) and at 1 sec (*SM*1), adjusted for Site Class effects, shall be determined by Eqns. 1.7 and 1.8 respectively.

$$SMS = Fa\ Ss \quad (1.7)$$
$$SM1 = Fv\ S1 \quad (1.8)$$

Design earthquake spectral response acceleration parameter at short period, *SDS*, and at 1 s period, *SD*1, shall be determined from Eqns. 1.9 and 1.10 respectively.

$$SDS = 2/3\ SMS \quad (1.9)$$
$$SD1 = 2/3\ SM1 \quad (1.10)$$

It is obvious that the IBC 2006 minimum design lateral force calculation is not as easy as UBC 1991.

2. COMPARISON OF THE BASE SHEAR NUMERICAL COEFFICIENT "Cs"

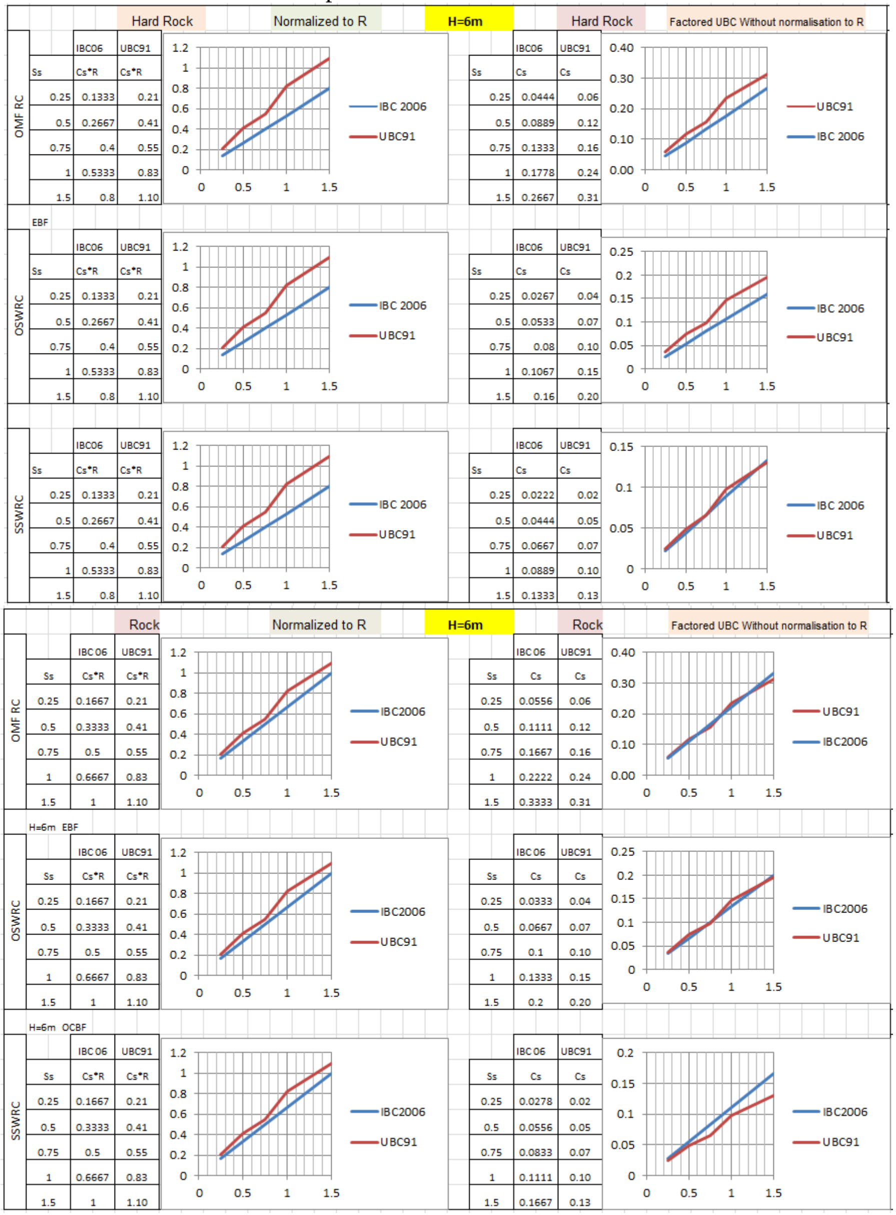
Base shear forces in IBC2006 and UBC1991 are based on the strength-level and allowable strength-level respectively. In order to compare base shear coefficient, different concrete structural systems in three groups with three different heights that is shown in Table 2.1 are considered.

Table 2.1. Different concrete structural system and heights

System	hn (m)		
OMFRC	6	30	45
OSWRC	6	30	45
SSWRC	6	30	45

The “C_S“ is calculated with and without normalizing to “R” due to big differences between two codes for the “R” values. The “R” values in UBC1991 are almost 1.6 times of the values provided in IBC2006, and in IBC2006 load combinations, earthquake force has 1.0 and 0.7 factors for LRFD (load and resistance factor design) and ASD method respectively. In order to take into account the strength and allowable strength levels for tow codes, the UBC1991 “C_S“ without normalizing to “R” is divided by 0.7. The C_S and C_S*R results for all three structural systems with different heights and different site classes plotted, and they are shown in Tables 2.1.

Tables 2.1. CS and CS/R comparison

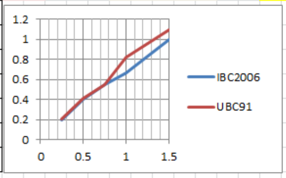


Tables 2.1. CS and CS/R comparison

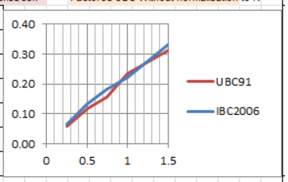
Very dense Soil | Normalized to R | H=6m | Very dense Soil | Factored UBC Without normalisation to R

OMF RC

	IBC 06	UBC91
Ss	Cs*R	Cs*R
0.25	0.2	0.21
0.5	0.4	0.41
0.75	0.55	0.55
1	0.6667	0.83
1.5	1	1.10

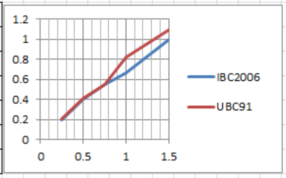


	IBC 06	UBC91
Ss	Cs	Cs
0.25	0.0667	0.06
0.5	0.1333	0.12
0.75	0.1833	0.16
1	0.2222	0.24
1.5	0.3333	0.31

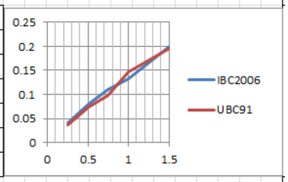


OSWRC

	IBC 06	UBC91
Ss	Cs*R	Cs*R
0.25	0.2	0.21
0.5	0.4	0.41
0.75	0.55	0.55
1	0.6667	0.83
1.5	1	1.10

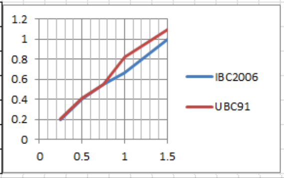


	IBC 06	UBC91
Ss	Cs	Cs
0.25	0.04	0.04
0.5	0.08	0.07
0.75	0.11	0.10
1	0.1333	0.15
1.5	0.2	0.20

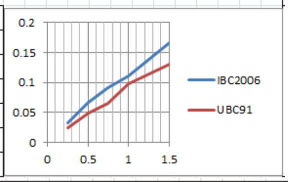


SSWRC

	IBC 06	UBC91
Ss	Cs*R	Cs*R
0.25	0.2	0.21
0.5	0.4	0.41
0.75	0.55	0.55
1	0.6667	0.83
1.5	1	1.10



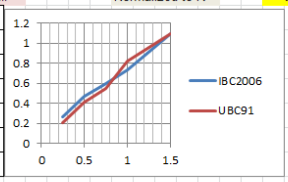
	IBC 06	UBC91
Ss	Cs	Cs
0.25	0.0333	0.02
0.5	0.0667	0.05
0.75	0.0917	0.07
1	0.1111	0.10
1.5	0.1667	0.13



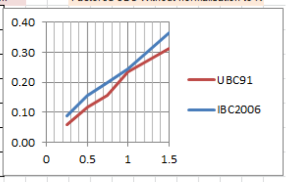
Stiff Soil | Normalized to R | H=6m | Stiff Soil | Factored UBC Without normalisation to R

OMF RC

	IBC 06	UBC91
Ss	Cs*R	Cs*R
0.25	0.2667	0.21
0.5	0.4667	0.41
0.75	0.6	0.55
1	0.7333	0.83
1.5	1.1	1.10

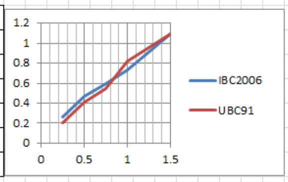


	IBC 06	UBC91
Ss	Cs	Cs
0.25	0.0889	0.06
0.5	0.1556	0.12
0.75	0.2	0.16
1	0.2444	0.24
1.5	0.3667	0.31

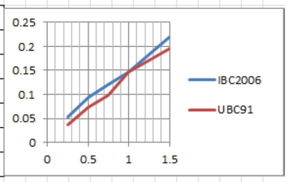


OSWRC

	IBC 06	UBC91
Ss	Cs*R	Cs*R
0.25	0.2667	0.21
0.5	0.4667	0.41
0.75	0.6	0.55
1	0.7333	0.83
1.5	1.1	1.10

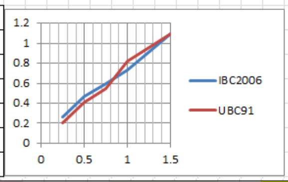


	IBC 06	UBC91
Ss	Cs	Cs
0.25	0.0533	0.04
0.5	0.0933	0.07
0.75	0.12	0.10
1	0.1467	0.15
1.5	0.22	0.20

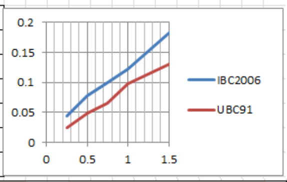


SSWRC

	IBC 06	UBC91
Ss	Cs*R	Cs*R
0.25	0.2667	0.21
0.5	0.4667	0.41
0.75	0.6	0.55
1	0.7333	0.83
1.5	1.1	1.10



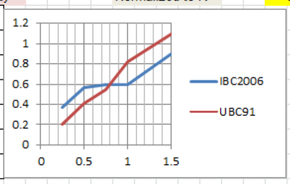
	IBC 06	UBC91
Ss	Cs	Cs
0.25	0.0444	0.02
0.5	0.0778	0.05
0.75	0.1	0.07
1	0.1222	0.10
1.5	0.1833	0.13



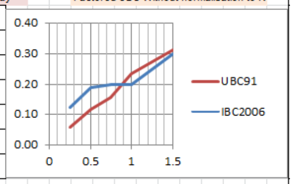
Soft Clay | Normalized to R | H=6m | Soft Clay | Factored UBC Without normalisation to R

OMF RC

	IBC 06	UBC91
Ss	Cs*R	Cs*R
0.25	0.3667	0.21
0.5	0.5667	0.41
0.75	0.6	0.55
1	0.6	0.83
1.5	0.9	1.10

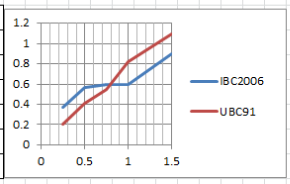


	IBC 06	UBC91
Ss	Cs	Cs
0.25	0.1222	0.06
0.5	0.1889	0.12
0.75	0.2	0.16
1	0.2	0.24
1.5	0.3	0.31

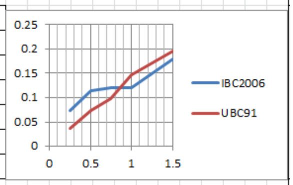


OSWRC

	IBC 06	UBC91
Ss	Cs*R	Cs*R
0.25	0.3667	0.21
0.5	0.5667	0.41
0.75	0.6	0.55
1	0.6	0.83
1.5	0.9	1.10

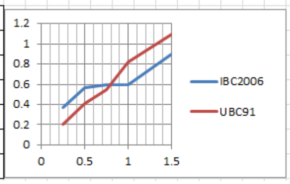


	IBC 06	UBC91
Ss	Cs	Cs
0.25	0.0733	0.04
0.5	0.1133	0.07
0.75	0.12	0.10
1	0.12	0.15
1.5	0.18	0.20

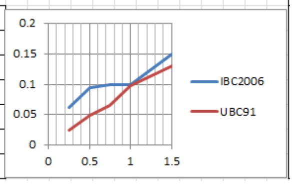


SSWRC

	IBC 06	UBC91
Ss	Cs*R	Cs*R
0.25	0.3667	0.21
0.5	0.5667	0.41
0.75	0.6	0.55
1	0.6	0.83
1.5	0.9	1.10



	IBC 06	UBC91
Ss	Cs	Cs
0.25	0.0611	0.02
0.5	0.0944	0.05
0.75	0.1	0.07
1	0.1	0.10
1.5	0.15	0.13

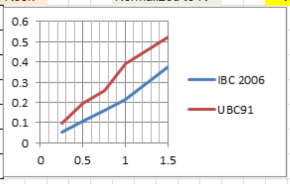


Tables 2.1. CS and CS/R comparison

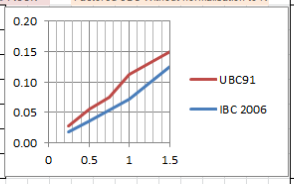
Hard Rock | Normalized to R | H=30m | Hard Rock | Factored UBC Without normalisation to R

OMF RC

	IBC 06	UBC91
Ss	Cs*R	Cs*R
0.25	0.0536	0.10
0.5	0.1072	0.20
0.75	0.1608	0.26
1	0.2144	0.39
1.5	0.3751	0.52

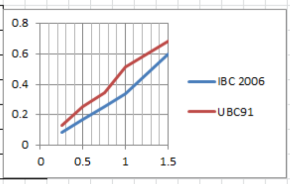


	IBC 06	UBC91
Ss	Cs	Cs
0.25	0.0179	0.03
0.5	0.0357	0.06
0.75	0.0536	0.07
1	0.0715	0.11
1.5	0.125	0.15

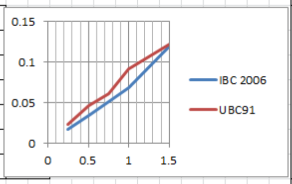


OSWRC

	IBC 06	UBC91
Ss	Cs*R	Cs*R
0.25	0.0853	0.13
0.5	0.1707	0.26
0.75	0.256	0.34
1	0.3413	0.51
1.5	0.5974	0.68

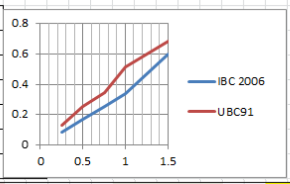


	IBC 06	UBC91
Ss	Cs	Cs
0.25	0.0171	0.02
0.5	0.0341	0.05
0.75	0.0512	0.06
1	0.0683	0.09
1.5	0.1195	0.12

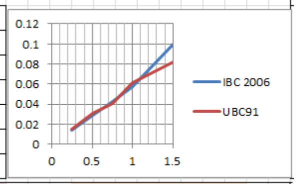


SSWRC

	IBC 06	UBC91
Ss	Cs*R	Cs*R
0.25	0.0853	0.13
0.5	0.1707	0.26
0.75	0.256	0.34
1	0.3413	0.51
1.5	0.5974	0.68



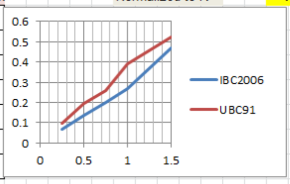
	IBC 06	UBC91
Ss	Cs	Cs
0.25	0.0142	0.02
0.5	0.0284	0.03
0.75	0.0427	0.04
1	0.0569	0.06
1.5	0.0996	0.08



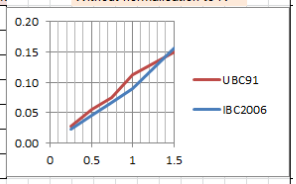
Rock | Normalized to R | H=30m | Rock | Without normalisation to R

OMF RC

	IBC 06	UBC91
Ss	Cs*R	Cs*R
0.25	0.067	0.10
0.5	0.134	0.20
0.75	0.201	0.26
1	0.2679	0.39
1.5	0.4689	0.52

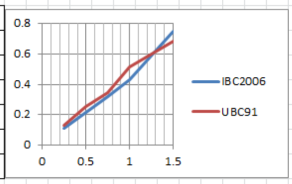


	IBC 06	UBC91
Ss	Cs	Cs
0.25	0.0223	0.03
0.5	0.0447	0.06
0.75	0.067	0.07
1	0.0893	0.11
1.5	0.1563	0.15

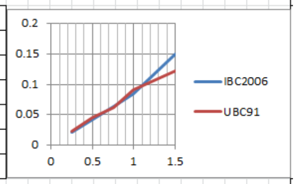


OSWRC

	IBC 06	UBC91
Ss	Cs*R	Cs*R
0.25	0.1067	0.13
0.5	0.2133	0.26
0.75	0.32	0.34
1	0.4267	0.51
1.5	0.7467	0.68

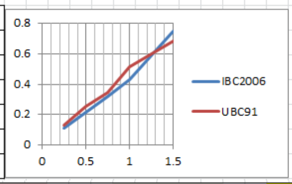


	IBC 06	UBC91
Ss	Cs	Cs
0.25	0.0213	0.02
0.5	0.0427	0.05
0.75	0.064	0.06
1	0.0853	0.09
1.5	0.1493	0.12

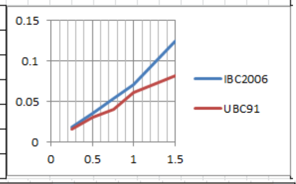


SSWRC

	IBC 06	UBC91
Ss	Cs*R	Cs*R
0.25	0.1067	0.13
0.5	0.2133	0.26
0.75	0.32	0.34
1	0.4267	0.51
1.5	0.7467	0.68



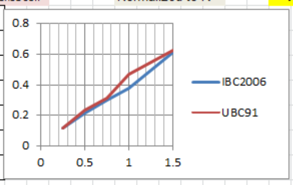
	IBC 06	UBC91
Ss	Cs	Cs
0.25	0.0178	0.02
0.5	0.0356	0.03
0.75	0.0533	0.04
1	0.0711	0.06
1.5	0.1245	0.08



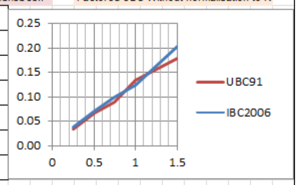
Very dense Soil | Normalized to R | H=30m | Very dense Soil | Factored UBC Without normalisation to R

OMF RC

	IBC 06	UBC91
Ss	Cs*R	Cs*R
0.25	0.1139	0.12
0.5	0.2144	0.23
0.75	0.3014	0.31
1	0.3751	0.47
1.5	0.6096	0.63

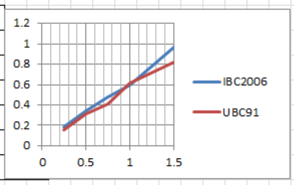


	IBC 06	UBC91
Ss	Cs	Cs
0.25	0.038	0.03
0.5	0.0715	0.07
0.75	0.1005	0.09
1	0.125	0.13
1.5	0.2032	0.18

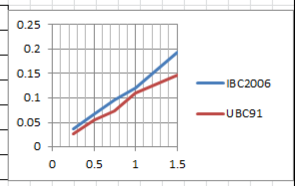


OSWRC

	IBC 06	UBC91
Ss	Cs*R	Cs*R
0.25	0.1813	0.15
0.5	0.3413	0.31
0.75	0.48	0.41
1	0.5974	0.62
1.5	0.9707	0.82

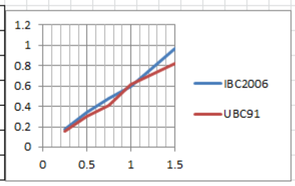


	IBC 06	UBC91
Ss	Cs	Cs
0.25	0.0363	0.03
0.5	0.0683	0.05
0.75	0.096	0.07
1	0.1195	0.11
1.5	0.1941	0.15

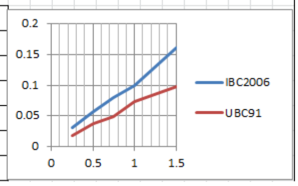


SSWRC

	IBC 06	UBC91
Ss	Cs*R	Cs*R
0.25	0.1813	0.15
0.5	0.3413	0.31
0.75	0.48	0.41
1	0.5974	0.62
1.5	0.9707	0.82



	IBC 06	UBC91
Ss	Cs	Cs
0.25	0.0302	0.02
0.5	0.0569	0.04
0.75	0.08	0.05
1	0.0996	0.07
1.5	0.1618	0.10

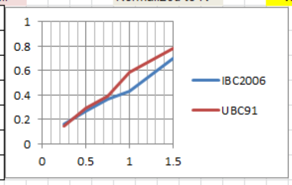


Tables 2.1. CS and CS/R comparison

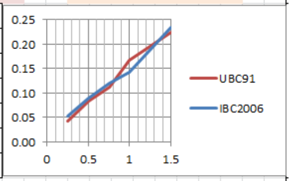
Stiff Soil — Normalized to R — H=30m — Stiff Soil — Factored UBC Without normalisation to R

OMF RC

	IBC 06	UBC91
Ss	Cs*R	Cs*R
0.25	0.1608	0.15
0.5	0.2679	0.29
0.75	0.3617	0.39
1	0.4287	0.59
1.5	0.7034	0.78

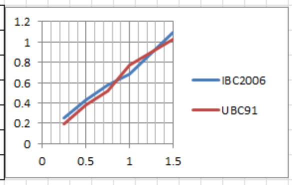


	IBC 06	UBC91
Ss	Cs	Cs
0.25	0.0536	0.04
0.5	0.0893	0.08
0.75	0.1206	0.11
1	0.1429	0.17
1.5	0.2345	0.22

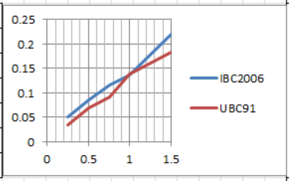


OSWRC

	IBC 06	UBC91
Ss	Cs*R	Cs*R
0.25	0.256	0.19
0.5	0.4267	0.38
0.75	0.576	0.51
1	0.6827	0.77
1.5	1.1	1.03

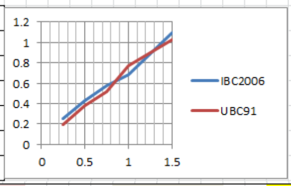


	IBC 06	UBC91
Ss	Cs	Cs
0.25	0.0512	0.03
0.5	0.0853	0.07
0.75	0.1152	0.09
1	0.1365	0.14
1.5	0.22	0.18

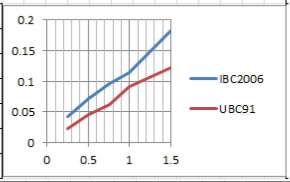


SSWRC

	IBC 06	UBC91
Ss	Cs*R	Cs*R
0.25	0.256	0.19
0.5	0.4267	0.38
0.75	0.576	0.51
1	0.6827	0.77
1.5	1.1	1.03



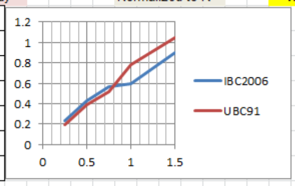
	IBC 06	UBC91
Ss	Cs	Cs
0.25	0.0427	0.02
0.5	0.0711	0.05
0.75	0.096	0.06
1	0.1138	0.09
1.5	0.1833	0.12



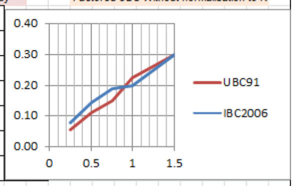
Soft Clay — Normalized to R — H=30m — Soft Clay — Factored UBC Without normalisation to R

OMF RC

	IBC 06	UBC91
Ss	Cs*R	Cs*R
0.25	0.2345	0.20
0.5	0.4287	0.39
0.75	0.5627	0.52
1	0.6	0.78
1.5	0.9	1.04

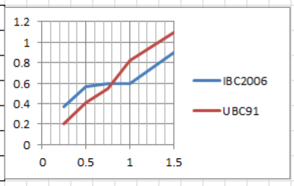


	IBC 06	UBC91
Ss	Cs	Cs
0.25	0.0782	0.06
0.5	0.1429	0.11
0.75	0.1876	0.15
1	0.2	0.22
1.5	0.3	0.30

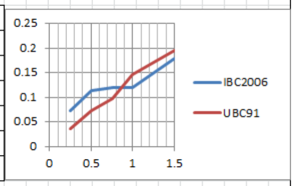


OSWRC

	IBC 06	UBC91
Ss	Cs*R	Cs*R
0.25	0.3667	0.21
0.5	0.5667	0.41
0.75	0.6	0.55
1	0.6	0.83
1.5	0.9	1.10

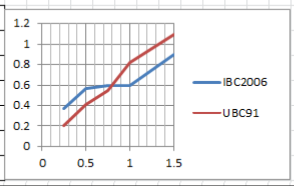


	IBC 06	UBC91
Ss	Cs	Cs
0.25	0.0733	0.04
0.5	0.1133	0.07
0.75	0.12	0.10
1	0.12	0.15
1.5	0.18	0.20

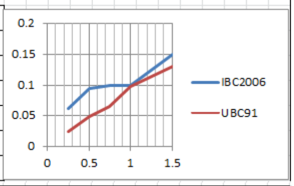


SSWRC

	IBC 06	UBC91
Ss	Cs*R	Cs*R
0.25	0.3667	0.21
0.5	0.5667	0.41
0.75	0.6	0.55
1	0.6	0.83
1.5	0.9	1.10



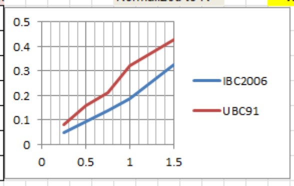
	IBC 06	UBC91
Ss	Cs	Cs
0.25	0.0611	0.02
0.5	0.0944	0.05
0.75	0.1	0.07
1	0.1	0.10
1.5	0.15	0.13



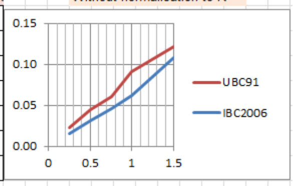
Rock — Normalized to R — H=45m — Rock — Without normalisation to R

OMF RC

	IBC 06	UBC91
Ss	Cs*R	Cs*R
0.25	0.0465	0.08
0.5	0.093	0.16
0.75	0.1395	0.21
1	0.186	0.32
1.5	0.3255	0.43

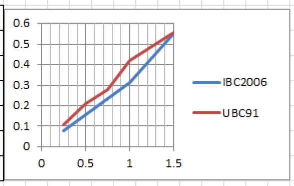


	IBC 06	UBC91
Ss	Cs	Cs
0.25	0.0155	0.02
0.5	0.031	0.05
0.75	0.0465	0.06
1	0.062	0.09
1.5	0.1085	0.12

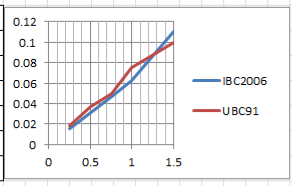


OSWRC

	IBC 06	UBC91
Ss	Cs*R	Cs*R
0.25	0.0787	0.10
0.5	0.1574	0.21
0.75	0.2361	0.28
1	0.3148	0.42
1.5	0.5509	0.56

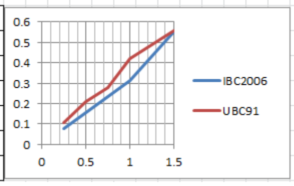


	IBC 06	UBC91
Ss	Cs	Cs
0.25	0.0157	0.02
0.5	0.0315	0.04
0.75	0.0472	0.05
1	0.063	0.07
1.5	0.1102	0.10

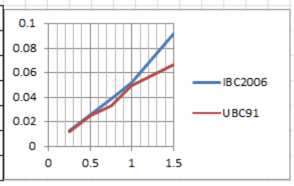


SSWRC

	IBC 06	UBC91
Ss	Cs*R	Cs*R
0.25	0.0787	0.10
0.5	0.1574	0.21
0.75	0.2361	0.28
1	0.3148	0.42
1.5	0.5509	0.56



	IBC 06	UBC91
Ss	Cs	Cs
0.25	0.0131	0.01
0.5	0.0262	0.02
0.75	0.0394	0.03
1	0.0525	0.05
1.5	0.0918	0.07

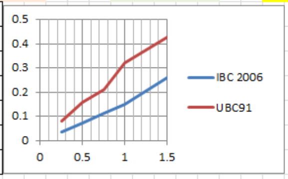


Tables 2.1. CS and CS/R comparison

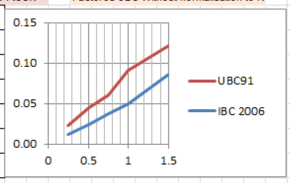
Hard Rock | Normalized to R | H=45m | Hard Rock | Factored UBC Without normalisation to R

OMF RC

Ss	IBC 06 Cs*R	UBC91 Cs*R
0.25	0.0372	0.08
0.5	0.0744	0.16
0.75	0.1116	0.21
1	0.1488	0.32
1.5	0.2604	0.43

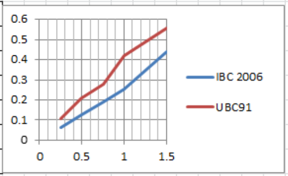


Ss	IBC 06 Cs	UBC91 Cs
0.25	0.0124	0.02
0.5	0.0248	0.05
0.75	0.0372	0.06
1	0.0496	0.09
1.5	0.0868	0.12

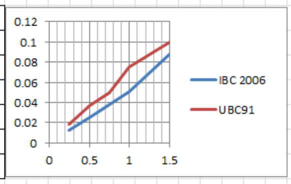


OSWRC

Ss	IBC 06 Cs*R	UBC91 Cs*R
0.25	0.063	0.10
0.5	0.1259	0.21
0.75	0.1889	0.28
1	0.2518	0.42
1.5	0.4407	0.56

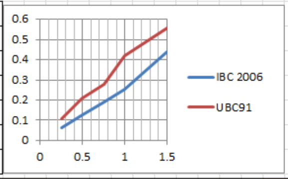


Ss	IBC 06 Cs	UBC91 Cs
0.25	0.0126	0.02
0.5	0.0252	0.04
0.75	0.0378	0.05
1	0.0504	0.07
1.5	0.0881	0.10

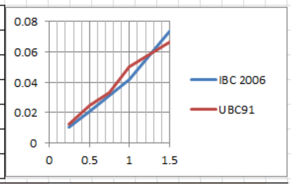


SSWRC

Ss	IBC 06 Cs*R	UBC91 Cs*R
0.25	0.063	0.10
0.5	0.1259	0.21
0.75	0.1889	0.28
1	0.2518	0.42
1.5	0.4407	0.56



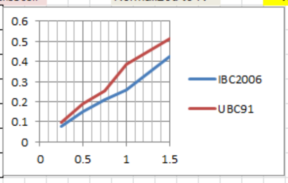
Ss	IBC 06 Cs	UBC91 Cs
0.25	0.0105	0.01
0.5	0.021	0.02
0.75	0.0315	0.03
1	0.042	0.05
1.5	0.0735	0.07



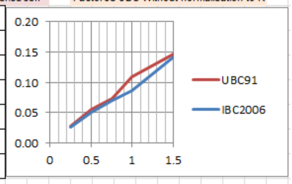
Very dense Soil | Normalized to R | H=45m | Very dense Soil | Factored UBC Without normalisation to R

OMF RC

Ss	IBC 06 Cs*R	UBC91 Cs*R
0.25	0.0791	0.10
0.5	0.1488	0.19
0.75	0.2093	0.26
1	0.2604	0.38
1.5	0.4232	0.51

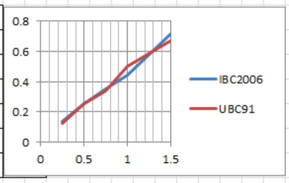


Ss	IBC 06 Cs	UBC91 Cs
0.25	0.0264	0.03
0.5	0.0496	0.05
0.75	0.0698	0.07
1	0.0868	0.11
1.5	0.1411	0.15

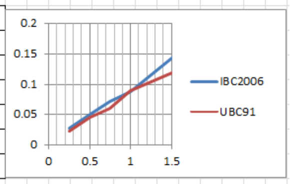


OSWRC

Ss	IBC 06 Cs*R	UBC91 Cs*R
0.25	0.1338	0.13
0.5	0.2518	0.25
0.75	0.3542	0.34
1	0.4407	0.50
1.5	0.7162	0.67

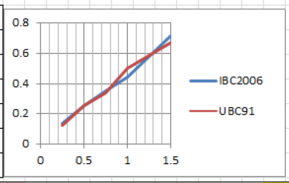


Ss	IBC 06 Cs	UBC91 Cs
0.25	0.0268	0.02
0.5	0.0504	0.04
0.75	0.0708	0.06
1	0.0881	0.09
1.5	0.1432	0.12

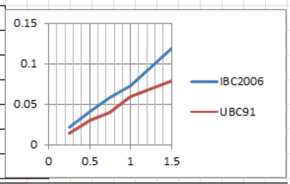


SSWRC

Ss	IBC 06 Cs*R	UBC91 Cs*R
0.25	0.1338	0.13
0.5	0.2518	0.25
0.75	0.3542	0.34
1	0.4407	0.50
1.5	0.7162	0.67



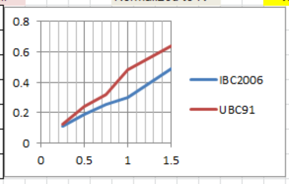
Ss	IBC 06 Cs	UBC91 Cs
0.25	0.0223	0.01
0.5	0.042	0.03
0.75	0.059	0.04
1	0.0735	0.06
1.5	0.1194	0.08



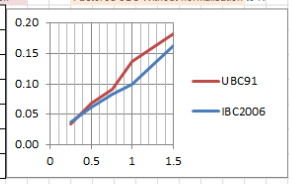
Stiff Soil | Normalized to R | H=45m | Stiff Soil | Factored UBC Without normalisation to R

OMF RC

Ss	IBC 06 Cs*R	UBC91 Cs*R
0.25	0.1116	0.12
0.5	0.186	0.24
0.75	0.2511	0.32
1	0.2976	0.48
1.5	0.4883	0.64

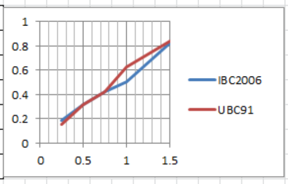


Ss	IBC 06 Cs	UBC91 Cs
0.25	0.0372	0.03
0.5	0.062	0.07
0.75	0.0837	0.09
1	0.0992	0.14
1.5	0.1628	0.18

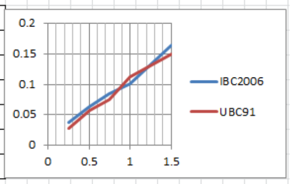


OSWRC

Ss	IBC 06 Cs*R	UBC91 Cs*R
0.25	0.1889	0.16
0.5	0.3148	0.31
0.75	0.425	0.42
1	0.5037	0.63
1.5	0.8264	0.84

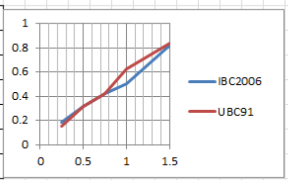


Ss	IBC 06 Cs	UBC91 Cs
0.25	0.0378	0.03
0.5	0.063	0.06
0.75	0.085	0.07
1	0.1007	0.11
1.5	0.1653	0.15



SSWRC

Ss	IBC 06 Cs*R	UBC91 Cs*R
0.25	0.1889	0.16
0.5	0.3148	0.31
0.75	0.425	0.42
1	0.5037	0.63
1.5	0.8264	0.84



Ss	IBC 06 Cs	UBC91 Cs
0.25	0.0315	0.02
0.5	0.0525	0.04
0.75	0.0708	0.05
1	0.0839	0.07
1.5	0.1377	0.10

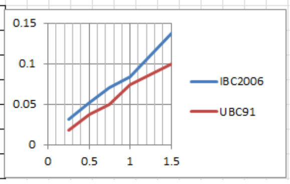
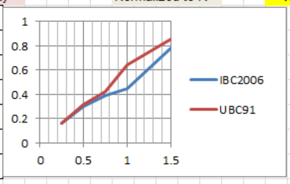
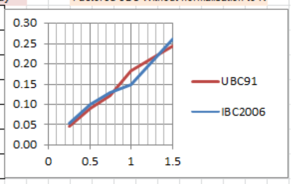


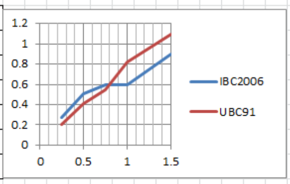
Table 2.1. CS and CS/R comparison

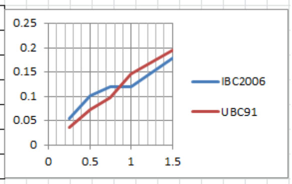
Soft Clay | Normalized to R | H=45m | Soft Clay | Factored UBC Without normalisation to R

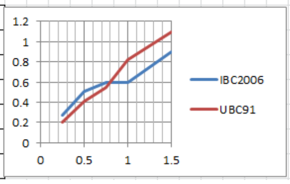
		IBC 06	UBC91	IBC 06	UBC91
	Ss	Cs*R	Cs*R	Cs	Cs
OMF RC	0.25	0.1628	0.16	0.0543	0.05
	0.5	0.2976	0.32	0.0992	0.09
	0.75	0.3907	0.43	0.1302	0.12
	1	0.4465	0.64	0.1488	0.18
	1.5	0.7813	0.85	0.2604	0.24
OSWRC	0.25	0.2755	0.21	0.0551	0.04
	0.5	0.5037	0.41	0.1007	0.07
	0.75	0.6	0.55	0.12	0.10
	1	0.6	0.83	0.12	0.15
	1.5	0.9	1.10	0.18	0.20
SSWRC	0.25	0.2755	0.21	0.0459	0.02
	0.5	0.5037	0.41	0.0839	0.05
	0.75	0.6	0.55	0.1	0.07
	1	0.6	0.83	0.1	0.10
	1.5	0.9	1.10	0.15	0.13

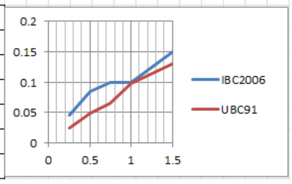












3. CONCLUSIONS

Base on the Tables 2.1:

1. It is clear that the normalized "C_S" to "R" results for two codes are almost similar.
2. The "C_S" values in IBC2006 are almost the same as UBC1991 with dividing the UBC1991 by 0.7 to bring the allowable strength level to the IBC2006 strength level.
3. By comparing the normalized and non-normalized "C_S" for two codes in Tables 2.1 it is clear that the results are almost similar.
4. The base shear force calculation based on the UBC1991 is acceptable, and the results would be equal or ± 20% based on the height or soil conditions.

REFERENCES

Uniform building code. 1991.
International building code. 2006.
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