SAFETY CHECK OF SONDUR DAM FOR CHANGED SEISMIC CONDITION

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ABSTRACT

The paper presents Seismic Hazard Analysis (SHA) of Sondur dam situated in Chhattisgarh in India, using CADAM. The purpose of present work is to foresee the impact of earthquakes on existing dam structure & to modify it by seismic retrofitting to improve their resistance to earthquake. The safety Analysis of existing concrete gravity dam is owing continous concern to dynamic seismic activities due to earthquake. These Earthquake results in change in seismic parameters due to tectonic movements. Action of earthquake is usually taken into account pseudo statically through inertia force characterized by a seismic coefficient. CADAM software has been primarily used for structural stability evaluation of concrete gravity dam using pseudo static method.

Sondur Dam, a major dam in Chhattisgarh state was constructed in the year 1988.The revised Seismic parameter, Peak Ground Acceleration for this site had been reported in the year 2006(khare, Pramod). With reference to the changed value of Peak Ground Acceleration, seismic hazard analysis for Sondur dam has been performed .The Dam section is checked for changed value of Peak Ground Acceleration for stability for various loading conditions and was found safe with the present study.

KEYWORDS

CADAM, Seismic hazard Analysis (SHA), PGA (Peak Ground Acceleration), Seismic Hazard.

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INTRODUCTION

Recent earthquakes in many part of the world lead to the need of properly designed engineered structure to withstand the seismic hazard. Seismic hazard is the physical effect that that occurs as a result of earthquake. There is a significant threat to human activities from the earthquake. Hence, it is required to design having their careful consideration. The main objective of seismic hazard analysis is to design, construct & maintain structures to perform at earthquake exposure up to the expectations & in compliance with the codes. Determination of Seismic Hazard

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basically involves Model analysis to compute seismic response of dam, Assessment based on experimental result & observation evidence, Seismic response analysis. Computation for determining seismic hazard was first formulated by C. Allin Cornell in 1968. Depending on their level of importance and use various studies has been performed in this area. Earthquake resistant design of concrete gravity dams (Chopra, A .K., 1978).Seismic hazard analysis, getting an estimate of the strong motion Parameters at a site for the purpose of earthquake resistant design or seismic safety Assessment (Gupta, 2002). A deterministic seismic hazard analysis for the major cultural heritage Sites Of Tamil Nadu, India (Ganapathy.G.P, 2010).

STUDY AREA

Dams are water retaining structure, used to manage or prevent water flow into specific land regions. . Dam failures and incidents involve unintended releases or surges of impounded water. They can destroy property and cause injury and death downstream. Sondur Dam is concrete dam constructed across river sondur 24°14' latitude and 82°06' longitude in Chhattisgarh, India. . The dam was completed in 1988, has a height of 38.5m, a crest thickness of 4.57m and a maximum base width of 129.846m.

Though Chhattisgarh have low rates of seismicity, but due to tremors from earthquakes in neighbouring states in recent years, minor seismic activity has been recorded. Bureau of Indian standards(BIS)has updated the Seismic hazard map of India in 2004.The main change in the seismic map of India for the state of Chhattisgarh is the merging zone I & II.since earthquakes data & their effect on existing structures are still incomplete .Hence it is necessary to have updated data .

METHODOLOGY

Seismic hazard analysis have been performed in CADAM to determine the(i)Safety margins considered against sliding along the considered joint (ii) The position of the all the resultant of forces acting on the joint. The analysis of present study involves:(i)Static Analyses: CADAM perform static analysis for the normal operating reservoir elevation or the flood elevation.(ii)Seismic Analyses: CADAM could perform seismic analysis using the pseudo-static method or the pseudo-dynamic method ..

The gravity method requires several assumptions regarding the structural behaviour of the dam and the application of the loads:Dam body is divided into lift joints of homogeneous properties along their length, the mass concrete and lift joints are uniformly elastic,

•Applied loads are transferred to the foundation by the cantilever action of the dam without interactions with adjacent monoliths

•There is no interaction between the joints,

•Each joint is analyzed independently from the others,

•Normal stresses are linearly distributed along horizontal planes

•Shear stresses follow a parabolic distribution along horizontal plane in the uncracked condition.

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SECTION GEOMETRY

Specifications of the overall dimensions of the section geometry i.e.

Dam's parameters has been re-generated from the software are given in Fig.1, Table-A & B

Table-A Salient Features

Geometry		
L1=	29.846	M
L2=	2.386	M
L3=	4.570	M
L4=	4.570	M
Elev. A=	0.000	M
Elev. B=	0.000	M
Elev. C=	0.000	M
Elev. D=	0.000	M
Elev. E=	0.000	M
Elev. F=	32.700	M
Elev. G=	38.200	M
Elev. H=	0.000	M
Elev. I =	0.000	M

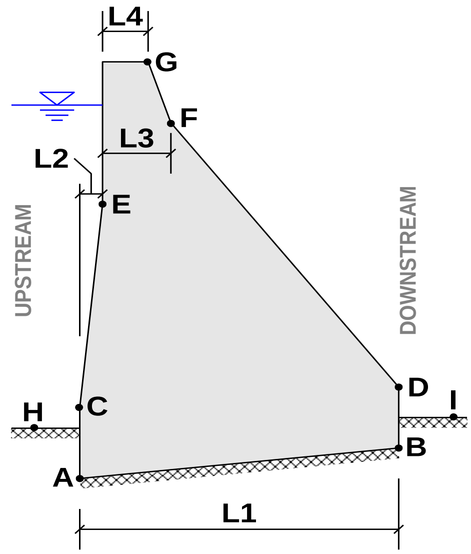

Figure 1 Dam Geometry

Table-B Reservoir Levels

Water Volumetric Mass		
r=	9.810	kg/m^3
Ice cover		
Load=	0	KN
Thickness=	0.000	m
Elevation=	35.000	m
Silts		
Elevation=	0.650	m
g'=	7	KN/m^3
f=	20	deg
Assumption=	at rest	

Reservoirs				
	Upstream side		Downstream side	
Normal operating level:	35.000	m	3.000	m
Flood level:	35.860	m	17.135	m
Crest overtopping pressure	100.00	%	50.00	%
Drainage system				
Gallery position from heel of dam=	5.446	m		
Gallery elevation=	3.000	m		
Drain Efficiency=	0.6667			
Highest drained elevation=	38.200	m		
Modelisation:	USBR 1987			

MATERIALS

Definition of tensile, compressive and shear strength of lift joints & base joints & rock joint are mentioned (Table-D).

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Table-D Material Properties

Lift Joint Material Properties							
	Concrete strength		**Peak friction**		**Residual friction**		Minimal compressive
Material	f'c	ft	Cohesion	Angle	Cohesion	Angle	stress for cohesion
Name	(kPa)	(kPa)	(kPa)	(deg)	(kPa)	(deg)	(kPa)
Base joint	14000	0	0	55	0	45	0
Base	14000	0	0	55	0	45	0

SEISMIC PARAMETERS CONSIDERED

On large Dams International committee (ICOLD) recommendations are followed while evaluating the seismic parameters (ICOLD, 1989); therefore consider Operating Basis Earthquake (OBE) and a Maximum Credible Earthquake (MCE).

The Operating Basis Earthquake (OBE) is defined as the earthquake producing the greatest level of ground motion with a 50 percent probability of being exceeded in 100 years

Maximum Credible Earthquake (MCE) is defined as the largest possible earthquake that could occur along the recognized faults or within a particular seismic source motion. By definition the MCE has a very low probability of occurrence. Ground motion associated with Krinitzsky (2005) highlights through his studies that a Deterministic Seismic Hazard Analysis (DSHA) uses geology and seismic history to identify & interrupt earthquake sources .As each source is capable of producing regardless of time, because that earthquake might happen tomorrow**.**

Seismic study of a dam site is done (i) by defining whether seismic loading of the structures must be incorporated to design or not. (ii) The usual basis for this initial assessment is the map of seismic activity.

The seismic parameters are re-generated from the software and given in Table C.

Table-C Seismic Coefficients

Pseudo-static (seismic coefficient)					
Horizontal Peak Ground Acceleration (HPGA)=	0.10	g	Earthquake return period=	2500	Years
Vertical Peak Ground Acceleration (VPGA)=	0.050	g	Earthquake accelerogram period (te)=	1	Sec
Horizontal Sustained Acceleration (HSA)=	0.050	g	Depth where pressures remain constant=	Generalized	
Vertical Sustained Acceleration (VSA)=	0.025	g	Westergaard correction for Inclined surface=	Corns et al.	

PSEUDO-STATIC ANALYSIS

Peak ground horizontal and vertical accelerations as well as the sustained accelerations specification. Westergaard added mass is used for representation of the hydrodynamic effects of the reservoir. Options are provided for (a) water compressibility effects (b) inclination of the upstream face (c) limiting the variation of hydrodynamic pressures. Hydrodynamic pressures for the silt are approximated from Westergaard formulation for a liquid of higher mass density than water (Fig.3).Pseudo static analysis is timely conducted by concerned engineers. It produces a scalar index of stability which depicts the static stability analyses.

LOAD COMBINATIONS

To form load combinations, Specification of user defined multiplication factors of basic load conditions.
Load combinations supports: Usual, flood, seismic 1, seismic 2 combination

REQUIRED SAFETY FACTORS

For each load combination, specified safety factors ensure an adequate safety margin for structural stability. These values are not used in the computational algorithm of the program. They are reported in the output results to compare safety factors in comparison with the corresponding allowable values.

ALLOWABLE STRESS FACTORS

For each load combination by applying multiplication factors to the tensile and compressive strengths allowable stresses could be defined. Various factors have been mentioned in dam safety guidelines to ensure an adequate safety margin to maintain structural stability. Allowable concrete stresses are reported in the output results to compare it with the corresponding allowable values

CASE STUDY & THEIR RESULT:

The stress & stability analysis for usual combination has been shown in Table-1 & 2 respectively whereas Table-3 & 4 shows the result of stress & stability analysis for flood condition. Similarly for seismic-1 condition stress analysis has been presented through Table-5 & 6 & stability analysis has been through Table 8 & 9.Table-7 & 8 presents the results for seismic -1 for sustained acceleration. Table 9-12 show result of stress & stability analysis for seismic -2 conditions.
The result shows that in all the condition Factor of safety for the overturning & sliding are quite higher than the safe values as per codes whereas stress are coming within permissible limit.

CONCLUSION

The results presented through this paper demonstrate that the response of concrete gravity dam is significantly affected by various static and dynamic loading parameters. The design check dam is performed for the present PGA value of 0.1g to assess whether seismic upgrading of a Sondur Dam is necessary from seismic safety point of view. It can be concluded from the present study that the dam section is safe for all possible load combinations and no further retrofitting is required.

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Table-1

USUAL COMBINATION (STRESS ANALYSIS)									
Joint	Stresses								
		Normal stresses		allowable stresses		Shear			
ID	Upstream	Upstream	Downstream	tension	Compression	Upstream	Maximum	Maximum at I-axis (% of joints)	Downstream
	(m)	(kPa)	(kPa)	(kPa)	(kPa)	(kPa)	(kPa)	(kPa)	(kPa)
1	35	-75.341	-75.341	0	-4662	-75.341	-75.341	0	-4662
2	30	-175.284	-76.884	0	-4662	-175.284	-76.884	0	-4662
3	25	-209.618	-110.844	0	-4662	-209.618	-110.844	0	-4662
4	20	-217.193	-188.765	0	-4662	-217.193	-188.765	0	-4662
5	15	-219.275	-278.731	0	-4662	-219.275	-278.731	0	-4662
6	10	-219.911	-373.331	0	-4662	-219.911	-373.331	0	-4662
7	5	-220.173	-470.099	0	-4662	-220.173	-470.099	0	-4662
8	Base	-176.18	-542.891	0	-4662	-176.18	-542.891	0	-4662

Table-2

USUAL COMBINATION (STABILITY ANALYSIS))									
Joint		Safety factors					Resultants		
ID	Upstream elevation	Sliding		Overturning		Uplifting	Normal	Shear	Moment
		Peak	Residual	Toward U/S	Toward D/S				
	(m)						(kN)	(kN)	(kN·m)
1	35	> 100	> 100	> 100	> 100	> 100	-344.3	0	0
2	30	9.486	6.642	10.375	4.782	7.37	-814.5	122.6	-342.2
3	25	4.647	3.254	9.293	3.252	6.1	-1595.9	490.5	-816.5
4	20	3.535	2.476	9.771	2.719	5.921	-2732.1	1103.6	-429.2
5	15	3.074	2.152	10.293	2.459	5.941	-4223.1	1962	1425.2
6	10	2.827	1.98	10.718	2.307	6.009	-6068.9	3065.6	5352
7	5	2.675	1.873	11.053	2.209	6.087	-8269.4	4414.5	11956.5
8	Base	2.569	1.799	6.665	1.982	4.257	-10730.7	5965.5	27221.6

Table-3

FLOOD COMBINATION (STRESS ANALYSIS)									
Joint	Stresses								
		Normal stresses		allowable stresses		Shear			
ID	Upstream	Upstream	Downstream	Tension	Compression	Upstream	Maximum	Maximum at I-axis (% of joints)	Downstream
	(m)	(kPa)	(kPa)	(kPa)	(kPa)	(kPa)	(kPa)	(kPa)	(kPa)
1	35	-66.605	-75.64	0	-7000	0	1.191	50	0
2	30	-149.79	-95.575	0	-7000	0	66.903	100	66.903
3	25	-175.51	-139.546	0	-7000	0	97.682	100	97.682
4	20	-178.35	-222.876	0	-7000	0	156.013	100	156.013
5	15	-167.77	-296.617	0	-7000	0	207.632	100	207.632
6	10	-140.9	-359.169	0	-7000	0	251.418	100	251.418
7	5	-122.2	-423.178	0	-7000	0	296.225	100	296.225
8	Base	-97.153	-477.244	0	-7000	0	334.071	100	334.071

Table-4

FLOOD COMBINATION (STABILITY ANALYSIS)										
Joint		**Safety factors**					**Resultants**				**Uplift**
ID	Upstream Elevation	**Sliding**		**Overturning**		**Uplifting**	**Normal**	**Shear**	**Moment**	**Position**	**Final Force**
		Peak	Residual	Toward U/S	Toward D/S						
	(m)						(kN)	(kN)	(kN·m)	(% of joint)	(kN)
1	35	> 100	89.596	26.826	13.162	17.86	-325	3.6	15.7	51.059	19.3
2	30	6.72	4.705	9.288	3.719	6.289	-792.5	168.4	-188.5	46.318	149.8
3	25	3.873	2.712	9.049	2.784	5.617	-1569	578.5	-297.3	48.097	339.9
4	20	3.126	2.189	9.705	2.427	5.599	-2700.3	1233.8	672.2	51.85	587.1
5	15	2.663	1.865	6.381	2.095	4.408	-3938	2112	3088.5	54.624	1155.5
6	10	2.411	1.688	3.933	1.794	3.187	-5115.7	3030.5	7614.3	57.275	2339.5
7	5	2.363	1.655	3.107	1.641	2.69	-6533.7	3948.9	14398.6	59.198	3866.9
8	Base	2.515	1.761	2.648	1.551	2.333	-8571.7	4868.4	28214.9	61.029	6430.9
Required:		2	1.3	1.1	1.1						

Table-5

SEISMIC #1 COMBINATION - PEAK ACCELERATIONS (STRESS ANALYSIS)

Joint	Stresses								
		Normal stresses		allowable stresses		Shear			
ID	Upstream	Upstream	Downstream	tension	Compression	Upstream	Maximum	Maximum at I-axis (% of joints)	Downstream
	(m)	(kPa)	(kPa)	(kPa)	(kPa)	(kPa)	(kPa)	(kPa)	(kPa)
1	35	-94.934	-63.281	0	-12726	0	-11.301	50	0
2	30	-250.639	-16.117	0	-12726	0	-5.201	35.969	11.282
3	25	-317.117	-22.51	0	-12726	0	27.023	60.765	15.757
4	20	-356.079	-74.302	0	-12726	0	59.224	74.129	52.011
5	15	-388.991	-138.955	0	-12726	0	98.609	89.56	97.269
6	10	-419.918	-208.908	0	-12726	0	146.235	100	146.235
7	5	-449.984	-281.585	0	-12726	0	197.11	100	197.11
8	Base	-407.77	-358.391	0	-12726	0	250.874	100	250.874

Table-6

SEISMIC #1 COMBINATION - PEAK ACCELERATIONS (STABILITY ANALYSIS)

Joint		Safety factors					Resultants				Uplift
ID	Upstream Elevation	Sliding		Overturning		Uplifting	Normal	Shear	Moment	Position	Final Force
		Peak	Residual	Toward U/S	Toward D/S						
	(m)						(kN)	(kN)	(kN·m)	(% of joint)	(kN)
1	35	14.996	10.5	14.995	> 100	> 100	-361.5	-34.4	-55.1	46.666	
2	30	> 100	> 100	3.886	5.577	7.739	-861.6	-6.8	-815.6	35.347	127.9
3	25	12.08	8.458	3.579	3.79	6.405	-1691.3	200	-2435.5	35.543	312.9
4	20	6.99	4.894	3.775	3.17	6.217	-2896.5	591.8	-4254.2	39.088	555.2
5	15	5.454	3.819	3.993	2.865	6.238	-4477	1172.3	-5993.4	42.107	854.8
6	10	4.727	3.31	4.182	2.686	6.31	-6432.9	1943.7	-7361	44.407	1211.5
7	5	4.305	3.015	4.34	2.569	6.392	-8764.2	2907.2	-8056.2	46.164	1625.5
8	Base	4.175	2.923	3.736	2.287	4.47	-11433.4	3911.2	-3665.5	48.926	3294.7
Required:			1.3	1	1.1	1.1	1.1				

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Table-7

SEISMIC #1 COMBINATION - SUSTAINED ACCELERATIONS (STRESS ANALYSIS)									
Joint	**Stresses**								
		Normal stresses		**allowable stresses**		**Shear**			
ID	Upstream	Upstream	Downstream	tension	Compression	Upstream	Maximum	Maximum at I-axis (% of joints)	Downstream
	(m)	(kPa)	(kPa)	(kPa)	(kPa)	(kPa)	(kPa)	(kPa)	(kPa)
1	35	-85.138	-69.311	0	-12726	0	-5.651	50	0
2	30	-212.962	-46.501	0	-12726	0	-0.732	12.912	32.55
3	25	-263.368	-66.677	0	-12726	0	48.339	84.346	46.674
4	20	-286.636	-131.533	0	-12726	0	92.299	95.283	92.073
5	15	-304.133	-208.843	0	-12726	0	146.19	100	146.19
6	10	-319.915	-291.119	0	-12726	0	203.784	100	203.784
7	5	-335.078	-375.842	0	-12726	0	263.089	100	263.089
8	Base	-291.975	-450.641	0	-12726	0	315.449	100	315.449

Table-8

SEISMIC #1 COMBINATION - SUSTAINED ACCELERATIONS (STABILITY ANALYSIS)											
Joint		**Safety factors**					**Resultants**				**Uplift**
ID	Upstream elevation	**Sliding**		**Overturning**		**Uplifting**	**Normal**	**Shear**	**Moment**	**Position**	**Final Force**
		Peak	Residual	Toward U/S	Toward D/S						
	(m)						(kN)	(kN)	(kN·m)	(% of joint)	(kN)
1	35	29.277	20.5	29.277	> 100	> 100	-352.9	-17.2	-27.5	48.292	
2	30	20.675	14.477	5.597	5.179	7.555	-838.1	57.9	-578.9	39.307	127.9
3	25	6.799	4.761	5.124	3.521	6.252	-1643.6	345.2	-1626	40.068	312.9
4	20	4.741	3.32	5.404	2.945	6.069	-2814.3	847.7	-2341.7	43.818	555.2
5	15	3.964	2.776	5.712	2.662	6.089	-4350	1567.2	-2284.1	46.904	854.8
6	10	3.564	2.496	5.974	2.497	6.159	-6250.9	2504.6	-1004.5	49.215	1211.5
7	5	3.323	2.326	6.19	2.389	6.239	-8516.8	3660.8	1950.1	50.956	1625.5
8	Base	3.205	2.244	4.765	2.134	4.364	-11082.1	4938.3	11778.1	53.561	3294.7
Required:		1.3	1	1.1	1.1						

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Table-9

SEISMIC #2 COMBINATION - PEAK ACCELERATIONS (STRESS ANALYSIS)									
Joint	**Stresses**								
		Normal stresses		**allowable stresses**		**Shear**			
ID	Upstream	Upstream	Downstream	tension	Compression	Upstream	Maximum	Maximum at I-axis (% of joints)	Downstream
	(kPa)	(kPa)	(kPa)	(kPa)	(kPa)	(kPa)	(kPa)	(kPa)	(kPa)
1	35.000	-94.934	-63.281	0.000	-12726.000	0.000	-11.301	50.000	0.000
2	30.000	-250.639	-16.117	0.000	-12726.000	0.000	-5.201	35.969	11.282
3	25.000	-317.117	-22.510	0.000	-12726.000	0.000	27.023	60.765	15.757
4	20.000	-356.079	-74.302	0.000	-12726.000	0.000	59.224	74.129	52.011
5	15.000	-388.991	-138.955	0.000	-12726.000	0.000	98.609	89.560	97.269
6	10.000	-419.918	-208.908	0.000	-12726.000	0.000	146.235	100.000	146.235
7	5.000	-449.984	-281.585	0.000	-12726.000	0.000	197.110	100.000	197.110
8	Base	-407.770	-358.391	0.000	-12726.000	0.000	250.874	100.000	250.874

Tabel-10

SEISMIC #2 COMBINATION - PEAK ACCELERATIONS (STABILITY ANALYSIS)										
Joint		**Safety factors**					**Resultants**				**Uplift**
ID	Upstream elevation	**Sliding**		**Overturning**		**Uplifting**	**Normal**	**Shear**	**Moment**	**Position**	**Final Force**
		Peak	Residual	Toward U/S	Toward D/S						
	(m)						(kN)	(kN)	(kN·m)	(% of joint)	(kN)
1	35	*15*	*10.5*	*15*	*> 100*	*> 100*	-361.5	-34.4	-55.1	46.666	
2	30	*> 100*	*> 100*	*3.886*	*5.577*	*7.739*	-861.6	-6.8	-815.6	35.347	127.9
3	25	*12.08*	*8.458*	*3.579*	*3.79*	*6.405*	-1691.3	200	-2435.5	35.543	312.9
4	20	*6.99*	*4.894*	*3.775*	*3.17*	*6.217*	-2896.5	591.8	-4254.2	39.088	555.2
5	15	*5.454*	*3.819*	*3.993*	*2.865*	*6.238*	-4477	1172.3	-5993.4	42.107	854.8
6	10	*4.727*	*3.31*	*4.182*	*2.686*	*6.31*	-6432.9	1943.7	-7361	44.407	1211.5
7	5	*4.305*	*3.015*	*4.34*	*2.569*	*6.392*	-8764.2	2907.2	-8056.2	46.164	1625.5
8	Base	*4.175*	*2.923*	*3.736*	*2.287*	*4.47*	-11433.4	3911.2	-3665.5	48.926	3294.7
Required		1.3	1	1.1	1.1	1.1					

Table-11

SEISMIC #2 COMBINATION - SUSTAINED ACCELERATIONS (STRESS ANALYSIS)									
Joint	**Stresses**								
		Normal stresses		**allowable stresses**		**Shear**			
ID	Upstream	Upstream	Downstream	tension	Compression	Upstream	Maximum	Maximum at I-axis (% of joints)	Downstream
	(kPa)	(kPa)	(kPa)	(kPa)	(kPa)	(kPa)	(kPa)	(kPa)	(kPa)
1	35.000	-85.138	-69.311	0.000	-12726.000	0.000	-5.651	50.000	0.000
2	30.000	-212.962	-46.501	0.000	-12726.000	0.000	-0.732	12.912	32.550
3	25.000	-263.368	-66.677	0.000	-12726.000	0.000	48.339	84.346	46.674
4	20.000	-286.636	-131.533	0.000	-12726.000	0.000	92.299	95.283	92.073
5	15.000	-304.133	-208.843	0.000	-12726.000	0.000	146.190	100.000	146.190
6	10.000	-319.915	-291.119	0.000	-12726.000	0.000	203.784	100.000	203.784
7	5.000	-335.078	-375.842	0.000	-12726.000	0.000	263.089	100.000	263.089
8	Base	-291.975	-450.641	0.000	-12726.000	0.000	315.449	100.000	315.449

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Vol. 1 Issue 5, July - 2012

Table-12

SEISMIC #2 COMBINATION - SUSTAINED ACCELERATIONS (STABILITY ANALYSIS)											
Joint		**Safety factors**					**Resultants**				**Uplift**
ID	Upstream elevation	**Sliding**		**Overturning**		**Uplifting**	**Normal**	**Shear**	**Moment**	**Position**	**Final Force**
		Peak	Residual	Toward U/S	Toward D/S						
	(m)						(kN)	(kN)	(kN·m)	(% of joint)	(kN)
1	35	29.277	20.5	29.277	> 100	> 100	-352.9	-17.2	-27.5	48.292	
2	30	20.675	14.477	5.597	5.179	7.555	-838.1	57.9	-578.9	39.307	127.9
3	25	6.799	4.761	5.124	3.521	6.252	-1643.6	345.2	-1626	40.068	312.9
4	20	4.741	3.32	5.404	2.945	6.069	-2814.3	847.7	-2341.7	43.818	555.2
5	15	3.964	2.776	5.712	2.662	6.089	-4350	1567.2	-2284.1	46.904	854.8
6	10	3.564	2.496	5.974	2.497	6.159	-6250.9	2504.6	-1004.5	49.215	1211.5
7	5	3.323	2.326	6.19	2.389	6.239	-8516.8	3660.8	1950.1	50.956	1625.5
8	Base	3.205	2.244	4.765	2.134	4.364	-11082.1	4938.3	11778.1	53.561	3294.7
Required:		1.3	1	1.1	1.1	1.1					