Analysis and Design of Turbo Generator Machine Foundation

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Abstract: *The analysis and design of machine foundation requires more consideration since it includes the static loads as well as the dynamic loads brought on by the working of machine. The constraining sufficiency and working recurrence of a machine are the most critical parameters to be considered in analysis of machine foundation. If the operating frequency of the machine matches the frequency of the foundation, then the foundation will become unstable and completely fail due to resonance. Over the time, there have been many analytical and mathematical solution for analysis and design of machine foundations. The objective of the study is to analyze a Turbo-Generator machine foundation by modelling the foundation using software staad pro and carrying out its dynamic and static analysis. The Turbo-Generator is also analyzed and design using analytical solution method.*

Keywords — *Turbo-generator, Foundation, software staad pro, Static analysis and Dynamic analysis, IS 2974Part-III (1992).*

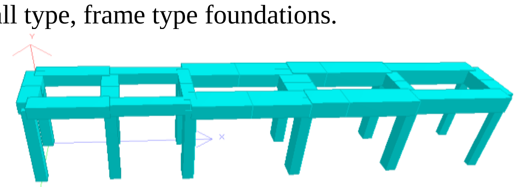
I. Introduction

The Design of machine foundation is more complex than that of foundations which underpins just static loads. In machine foundation, the originator must consider, notwithstanding the static loads , the dynamic strengths brought on by working of the machine. These dynamic powers are, thusly, transmitted to the foundation supporting the machine. The designer ought to, in this way, be well familiar with the strategy for load transmission from the machine and also with the issues concerning the dynamic conduct of the foundation and the soil underneath the establishment.

That the learning in this field has logged behind different branches of innovation is incompletely because of the way that the obligation regarding satisfactory execution of a machine is separated between the machine designer, who is normally a mechanical specialist, and the foundation designer, whose assignment is to outline a reasonable foundation reliable with the mechanical necessities and fulfilling the required resiliences. It is, in this way, attractive that the mechanical and structural specialists work in close coordination from the arranging stage until the apparatus is introduced on the foundation.

until recently, the practice in outline workplaces for the plan of machine foundation has been altogether in view of experimental tenets, since next to no was thought about the conduct of foundation subjected to dynamic loads. Which improvements in the fields of soil and auxiliary progression, the outline rule were step by step set up without reliance on insignificant exact techniques. The protest of this manual is to show these outline criteria in such a way, to the point that the originator may discover them helpful for application to down to earth issues.

Turbo-Generator is a power generator apparatus, generating power put in power plants. Turbo-generator foundation is an exceptionally complex building auxiliary part. Diverse sorts of turbo-generator foundation are utilized for various machines relying upon machines limit, geometrical sizes and constructional highlights. Dynamic conduct of the foundation assumes a critical part in giving ordinary working conditions to the bolstered turbo-generator. The foundation not exclusively ought to have an adequate bearing ability to bolster the turbo-generator machine and its assistant gear, additionally be intended to constrain the vibration amplitudes of the blades, the rotors and the course inside the worthy level. RC turbo-generator floor involves best deck, supporting structure and a separated foundation framework. All the gear of force plant including turbine, generator, and other mechanical-electrical instruments are situated on top of the deck. This foundation comprises of a detached specifically laying on solid soil. The distinctive sorts of foundations are block type, box or caisson type, wall type, frame type foundations.



Framed type foundation

The frame type foundations are most popular because of saving in space, saving in materials, easy accessibility to all machine parts for inspection and less liability to cracking due to settlement and temperature changes.

In this paper a turbo-generator deck has been prepared using software STAAD Pro. There are many ways of representing the model of a frame foundation using beam elements, solid elements or a combination of all of these each with its associated limitations. The obvious choice for the super structure is to model it as a space frame where the beams and columns are idealized as beam elements having six degrees of freedom at each node.

II. METHODOLOGY

The methodology incorporates displaying of the turbo generator foundation as a space frame where top deck beams and columns are idealised utilizing STAAD Pro programming. Dynamic examination on the model has been performed to locate the regular frequency of the foundation in each of the three bearings alongside most extreme adequacy of vibration in even and vertical headings. Static investigation has been performed on a similar model and outline of top deck beams and segments has been completed utilizing the consequences of this examination.

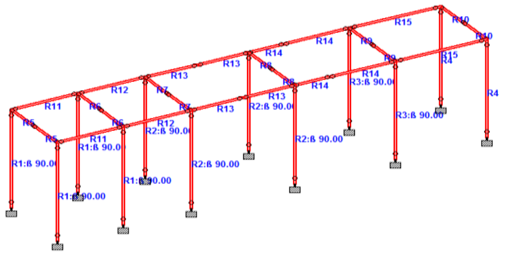


Fig. 1: Top Deck Beam Model

Fig. 1 shows the STAAD Pro model of top deck of foundation in which beams and columns are idealized as beam elements and the extended cantilever projections.

III. THEORETICAL FORMULATION

(1) ***Dynamic Analysis***

Because of unsuitable adjusting of turning parts by and by the mass centroid of pivoting part does not concur with focal point of revolution. Over the span of operation the underlying deficient adjusting possibly expanded at a disturbing rate in outcome of the slackening, erosion or breakage of the turbine sharp edges. Likewise the imperfections of the oil framework, lack of the pressing and uneven warming up of pivoting parts may bring about development bringing about vibrations which don't take after straightforward consonant movement. In this way unbalancing powers are delivered of the frame,

F (t) = Fo sin (wt+Φ) as shown in Fig. 2 below.

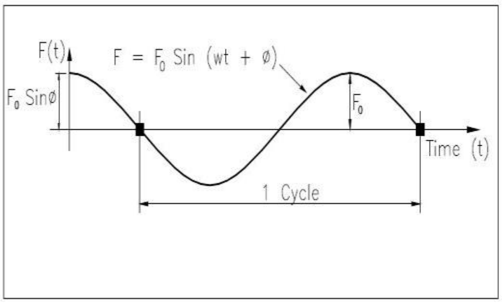


Fig. 2 Simple Harmonic Motion

Fo= (meω2) x F.O.S.

Where,

m- Mass of rotor,

e- Eccentricity in mm,

ω – Operating speed of machine (turbo- generator) in radian/sec

F.O.S- Fatigue factor is taken as 2 as per IS 2974 (part3):1992

The eccentricity of rotor mass can be obtained from, G=eω

Where ,G – Balance quality grade in mm/s .

The unbalance forces obtained as per the above formula for turbo-generator are then entered as harmonic forces in STAAD Pro. for doing the Time history analysis.

(2) Static Analysis

Primary load cases taken for static analysis are:

(i) Dead load(ii) Static load(iii) Static torque load(iv) Thermal expansion load (v) Dynamic load (vi) Short circuit load(vii) Temperature load (xiii) Shrinkage load (ix) Seismic X (x) Seismic Z

Load combinations considered

Operating condition

DL + OL + TLF+NUL

Short circuit condition

DL + OL+NUL+TLF+SCF

Loss of blade condition

DL + OL + TLF/SHRK + LBL/BFL

Seismic condition

DL + OL + TLF+SCL + EQL

Where,

DL Dead Loads

SL Static Loads (including static load and static torque load)

OL Operating Loads (including thermal expansion load, static loads, dynamic loads)

LBL Loss of Blade Condition

TLF Temperature Loads

SCF Short circuit Loads

SHRK Shrinkage Loads

EQL Seismic Loads

Dead load incorporates self-weight of the foundation and weight of machines and its auxiliaries. Self-weight of top deck and sections is connected utilizing self-weight command in STAAD Pro.

Static loads, working loads, loss of blade condition loads, short circuit loads were taken by producer's details. Temperature load was taken considering temperature distinction of 20C top deck . To represent the Shrinkage of the upper deck slab with respect to the base a temperature distinction of 10C has been considered. For plan of top deck beams Mz, My and torsion comes about because of programming were taken and entered in exceed expectations spread sheets. Working anxiety strategy was utilized for design. Same load cases and blends were utilized as a part of static analysis. For longitudinal reinforcement in top deck,

Equivalent bending moment,

Mze = Mz + Mt Mt = T (1 + D/b)/1.7

The following interaction equation should be satisfied

$\frac{M_{ze}}{M_{ze1}} + \frac{M_y}{M_y} < 1$

For shear, Equivalent shear, VC = (V+1.6 T/b)

IV. RESULTS

The natural frequencies of the foundation in all three directions were obtained by doing time history analysis in STAAD pro. The results are shown in table no 1 below.

MODE	FREQUENCY(CYCLES/SEC)	PERIOD(SEC)	ACCURACY
1	1.871	0.53449	0.000E+00
2	2.618	0.38193	2.100E-16
3	3.084	0.32424	4.541E-16
4	7.176	0.13935	1.331E-14
5	11.916	0.08392	4.226E-08
6	13.269	0.07537	1.155E-07
7	15.310	0.06532	2.279E-10
8	19.245	0.05196	4.613E-07

MASS PARTICIPATION FACTORS IN PERCENT

MODE	X	Y	Z	SUMM-X	SUMM-Y	SUMM-Z
1	100.00	0.00	0.00	99.998	0.000	0.000
2	0.00	0.00	2.82	99.998	0.000	2.824
3	0.00	0.00	96.83	99.998	0.000	99.649
4	0.00	0.00	0.29	99.998	0.000	99.935
5	0.00	0.00	0.00	99.998	0.000	99.935
6	0.00	0.00	0.00	99.998	0.000	99.935

Table No.1 Frequency Summary & Mass Participation Factors

S.no.	Cases	Amplitude of Vibration in mm					
		Turbine Side			Generator Side		
		Amp from STAAD	Permissible amp	Remarks	Amp from STAAD	Permissible amp	Remarks
1	Vertical vibrations - Y	0.003	0.04	O.K.	0.015	0.01	O.K.
2	Horizontal vibrations- Z	0.05	0.04	O.K.	0.025	0.02	O.K.

Table no.2: Amplitude summary

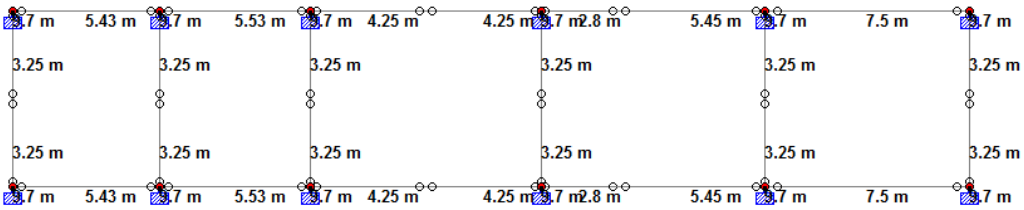


Fig 3: Top deck beam layout

All | Max Axial Forces | Max Bending Moments | Max Shea

Beam	L/C		Dist m	Mz kNm	Dist m	My kNm
1	1 (DL+OL) S	Max +ve	0.000	56.501	9.700	23.825
		Max -ve	9.700	-115.656	0.000	-8.555
	2 seismic loa	Max +ve	9.700	0.054	0.000	257.193
		Max -ve	0.000	-0.062	9.700	-248.503
	3 seismic loa	Max +ve	9.700	155.959	0.000	0.143
		Max -ve	0.000	-167.140	9.700	-0.006
	4 SHRINKAG	Max +ve	9.700	30.479	0.000	118.799
		Max -ve	0.000	-35.060	9.700	-114.437
	5 SEISMIC LO	Max +ve	9.700	0.039	0.000	183.709
		Max -ve	0.000	-0.044	9.700	-177.502
	6 SEISMIC LO	Max +ve	9.700	111.399	0.000	0.102
		Max -ve	0.000	-119.386	9.700	-0.005
	7 SHORT CIR	Max +ve	9.700	13.920	9.700	5.728
		Max -ve	0.000	-14.747	0.000	-5.763
	8 DL+OL	Max +ve	0.000	84.752	9.700	35.737
		Max -ve	9.700	-173.483	0.000	-12.832
	9 Shrinkage I	Max +ve	9.700	42.671	0.000	166.319
		Max -ve	0.000	-49.084	9.700	-160.211
	10 short circ	Max +ve	9.700	19.488	9.700	8.020
		Max -ve	0.000	-20.645	0.000	-8.068
	11 EQUIVAL	Max +ve	0.000	21.216	0.000	1.167
		Max -ve	9.700	-43.428	9.700	-0.046
	12 Equivalent	Max +ve	0.000	29.702	0.000	1.634
		Max -ve	9.700	-60.799	9.700	-0.065

Table no.3: Summary of bending moments under operating condition

According to IS 2974(Part3):1992 the fundamental natural frequency shall be at least 20 percent away from the machine operating speed. From the above table it can be seen that the conditions are satisfied everywhere. Apart from these the maximum amplitude of vibration of the foundation should be less than the limits specified by the manufacturer. Table no. 2 shows the amplitudes of vibration in both horizontal and vertical directions.

The fundamental objective in the design of a machine foundation is to farthest point its movement to amplitudes that neither endanger the attractive operation of the machine nor disturb individuals working in the immediate region. In above table most extreme amplitudes of the machines in their territories of impact was acquired by doing dynamic time history examination in programming STAAD Pro and contrasted and producer's determinations. In all cases conditions were observed to be satisfied.

VI. CONCLUSIONS

The RC turbine foundation has been effectively broke down by time history analysis utilizing STAAD Pro. The natural frequency of the foundation which is much lower than the working frequencies of turbo-generator machine. Reverberation condition can be maintained a strategic distance from with great dimensioning and outline of the different auxiliary parts. The plentifulness of vibration of machine from STAAD Pro for turbo-generator are inside cutoff points indicated by maker. The outline of top deck shafts has been done by IS 2974(part 3):1992 and it has been found that the measurements of beams are alright.

VII. REFERENCES

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