Centrale di San Filippo del Mela

Progetto definitivo per l'installazione di un nuovo ciclo combinato a gas

Note di calcolo - Turbogas

APPLICA

A2A/DGE/BGT/GEN/ING

LISTA DI DISTRIBUZIONE

A2A/DGE/BGT/GEN/ING
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ORDINE DEGLI INGEGNERI DELLA PROVINCIA DI MILANO
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a2a energiefuture

LOGO E CODIFICA DEL FORNITORE

TECHINT
Engineering & Construction

0421-TITA-C-CA-000-001

EMISSIONE					
1	10/12/2019	FU = Per Uso	C. Bettoni	D. Morgera	P. Coletti
0	26/11/2019	FA = Per Approvazione	L. Agostino	C. Bettoni	G. Ricci
REV	DATA	DESCRIZIONE	REDAZIONE	VERIFICA	APPROVAZIONE

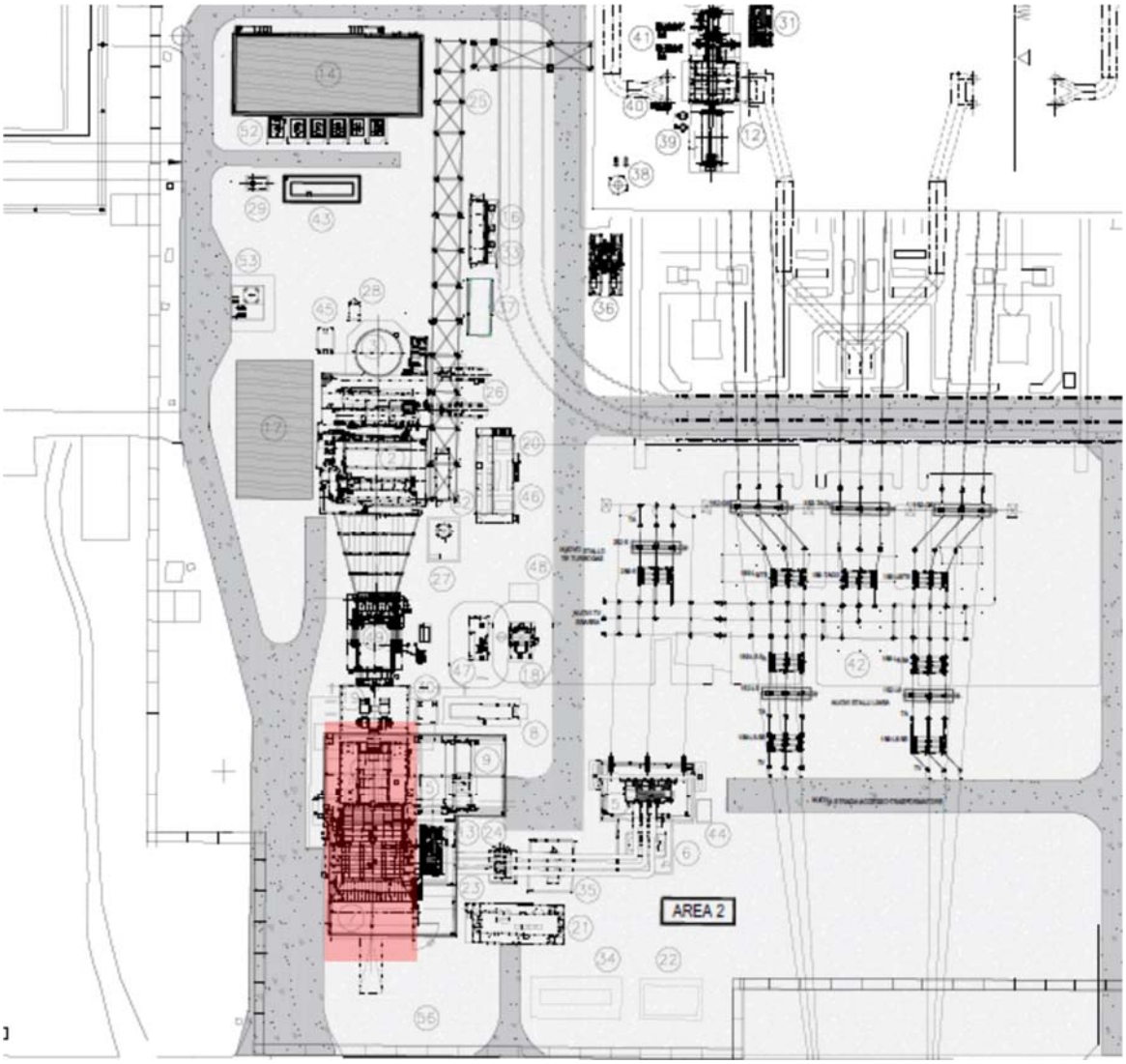
- Il documento approvato e firmato in originale è depositato presso l'archivio tecnico della S.O.-

INDICE

1 SCOPO

Lo scopo del presente documento riguarda l'analisi e predimensionamento della Fondazione della nuova turbina a gas relativa al Nuovo Ciclo Combinato a gas.

La fondazione è localizzata nell'area seguente:



2 PARAMETRI DI PROGETTAZIONE

2.1 DOCUMENTI DI RIFERIMENTO

NORMATIVE

1 Decreto ministeriale 17 gennaio 2018 - AGGIORNAMENTO "Norme tecniche per le costruzioni".

2 Circolare 21 gennaio 2019, nr. 7 - "Istruzioni per l'applicazione dell'aggiornamento delle Norme tecniche per le costruzioni".

3 UNI EN 1992-1: Eurocodice 2 – Progettazione delle strutture di calcestruzzo - Parte 1-1: Regole generali e regole per gli edifici

RELAZIONI E SPECIFICHE TECNICHE

4 SFP-RTC-100004-CCGT-00 Relazione Sismica

5 SFP-RTC-100005-CCGT-00 Relazione Geotecnica

2.2 SOFTWARES

STAAD.Pro Advanced – 2017 Bentley Systems.

2.3 MATERIALI

2.3.1 CALCESTRUZZO

C 35/45

• resistenza caratteristica cilindrica	f_{ck} =	35	MPa
• resistenza caratteristica cubica	R_{ck} =	45	MPa
• resistenza media a compressione	f_{cm} =	43	MPa
• resistenza media a trazione	f_{ctm} =	3.20	MPa
• modulo di elasticità secante	E_{cm} =	34077	MPa

2.3.2 ACCIAIO D'ARMATURA

Barre ad aderenza migliorata, saldabile, tipo ***B450C*** dotato delle seguenti caratteristiche meccaniche:

- modulo elastico E_s = 210000 MPa
- Tensione caratteristica di snervamento f_{yk} = 450 MPa
- Tensione caratteristica di rottura f_{tk} = 540 MPa

2.4 PARAMETRI AZIONE DELLA NEVE

- q_{sk} = 0.6KN/m^2 (si veda Fig. 3.4.1 di [1])
- C_e = 1
- C_t = 1
- μ_1 = 0.8
- q_s = 0.48 = KN/m^2

2.5 PARAMETRI AZIONE DEL VENTO

Considerando zona 4 (si veda Tab. 3.3.I di [1]):
- $v_{b,0}$ = 28 m/s
- a_0 = 500 m
- ks = 0.36

Essendo il sito situato a circa 89 m slm, la velocità base di riferimento sarà pari a:
$v_b = c_a\ v_{b,0}$ = 1 * 28 m/s= 28m/s.
La velocità di riferimento sarà pari a: vr = $v_b\ c_r$ = 28 * 1= 28m/s.

Considerando una categoria di esposizione II (si veda Tab. 3.3.II di [1]):
- kr = 0.19
- z0 = 0.05 m
- zmin = 4 m

Per tanto, la pressione del vento sarà data dalla seguente espressione:

$$p = q_r\ c_e\ c_p\ c_d$$

dove:
- qr = 490 N/m2
- Cd = 1
- Ct = 1
- Ce (z): coefficiente di esposizione.
- Cp: coeff. di pressione (si veda [2])

2.6 PARAMETRI AZIONE SISMICA

- si veda [4]:

		ag (g)	F0	Tc* (sec)
SLO	30	0.053	2.415	0.277
SLD	50	0.066	2.423	0.301
SLV	476	0.159	2.527	0.374
SLC	976	0.201	2.567	0.404

- **Categoria di sottosuolo C**: Depositi di terreni a grana grossa mediamente addensati o terreni a grana fina mediamente consistenti, a cui corrisponde un coefficiente d'amplificazione stratigrafica (S_S) pari a 1.50
- **Categoria topografica T1:** superficie pianeggiante, a cui corrisponde un coefficiente di amplificazione topografica (S_T) pari a 1.00.

3 DESCRIZIONE

3.1 FILOSOFIA DI PROGETTAZIONE

La Fondazione è costituita da una platea su pali con diversi pedestals a supporto delle diverse parti della macchina. Tali elementi sono stati modellati come elementi a piastra.

Dal momento che dati di input ufficiali per il progetto Nuovo Ciclo Combinato a gas non sono disponibili, sono stati considerati input ricavati da progetti equivalenti del passato (in Allegato A, sono riportati dati di input considerati per lo sviluppo della progettazione).

Le analisi strutturali sono state condotte assicurando che la frequenza della struttura non rientri nell'intervallo compreso tra 0.80÷1.20 volte la frequenza della macchina [Paragr. 5.3.2 - DIN 4024_Part 1] :

5.3.2 Assessment of vibration behaviour on the basis of natural vibration

An assessment of the vibration behaviour of a machine foundation, in respect of the objectives given in subclause 5.1.1, may, as a simplification, be based on the relationship of the natural frequencies, f_n, to the service frequencies, f_m.

If both conditions 1 and 2 below are met for each decoupled model, subsequent analysis may be dispensed with.

1. First order natural frequency

$$f_1 \geq 1{,}25 \cdot f_m \qquad (13)$$

or

$$f_1 \leq 0{,}8 \cdot f_m \qquad (14)$$

Sono stati adottati pali da 800mm di diametro considerando un interasse pari a 3 diametri.

I pali sono stati modellati come molle, adottando i valori esplicitati in [4].

Per la scelta progettuale adottata (palo D=800 mm, L=20 m), si riporta il riepilogo delle seguenti informazioni:

- Resistenza di progetto del singolo palo a compressione ($R_{c,d}$)/trazione ($R_{t,d}$) agli SLU - **Error! Reference source not found.**
- Rigidezza assiale del singolo palo (K_v) - Tabella 2;
- Resistenza di progetto del palo singolo ad azioni orizzontali ($R_{tr,d}$) - Tabella **3**;
- Rigidezza orizzontale del singolo palo (K_h).

		Approccio 2 (A1+M1+R3)		**Approccio 2 (A1+M1+R3)**	
D	**L_{palo}**	**Rd,compr ($R_{d,c}$)**	**Rd,traz ($R_{d,t}$)**	**Rd,comp - (Wp - Ws)**	**Rd,traz+ Wp**
(m)	**(m)**	**(kN)**	**(kN)**	**(kN)**	**(kN)**
0,8	20,0	3049,64	1596,67	2977,76	1873,13

Tabella 1 – Riepilogo Capacità portanti a compressione/trazione agli SLU

D	L	N_{SLE}	Kv
[m]	[m]	[kN]	[kN/mm]
0,8	20	1600	200

Tabella 2 – Rigidezza assiale e massimo carico verticale di esercizio

D	L	$R_{tr,d}$
[m]	[m]	[kN]
0,8	20	203

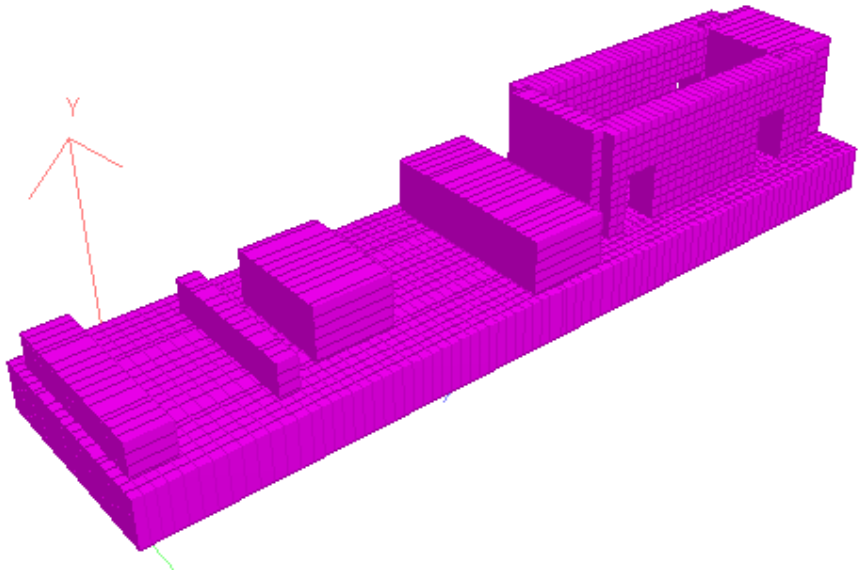
Tabella 3 – Resistenza del palo ad azioni orizzontali agli SLU

D	L	H_{SLE}	Kh
[m]	[m]	[kN]	[kN/mm]
0,8	20	142,50	18

Tabella 4 – Rigidezza orizzontale del palo

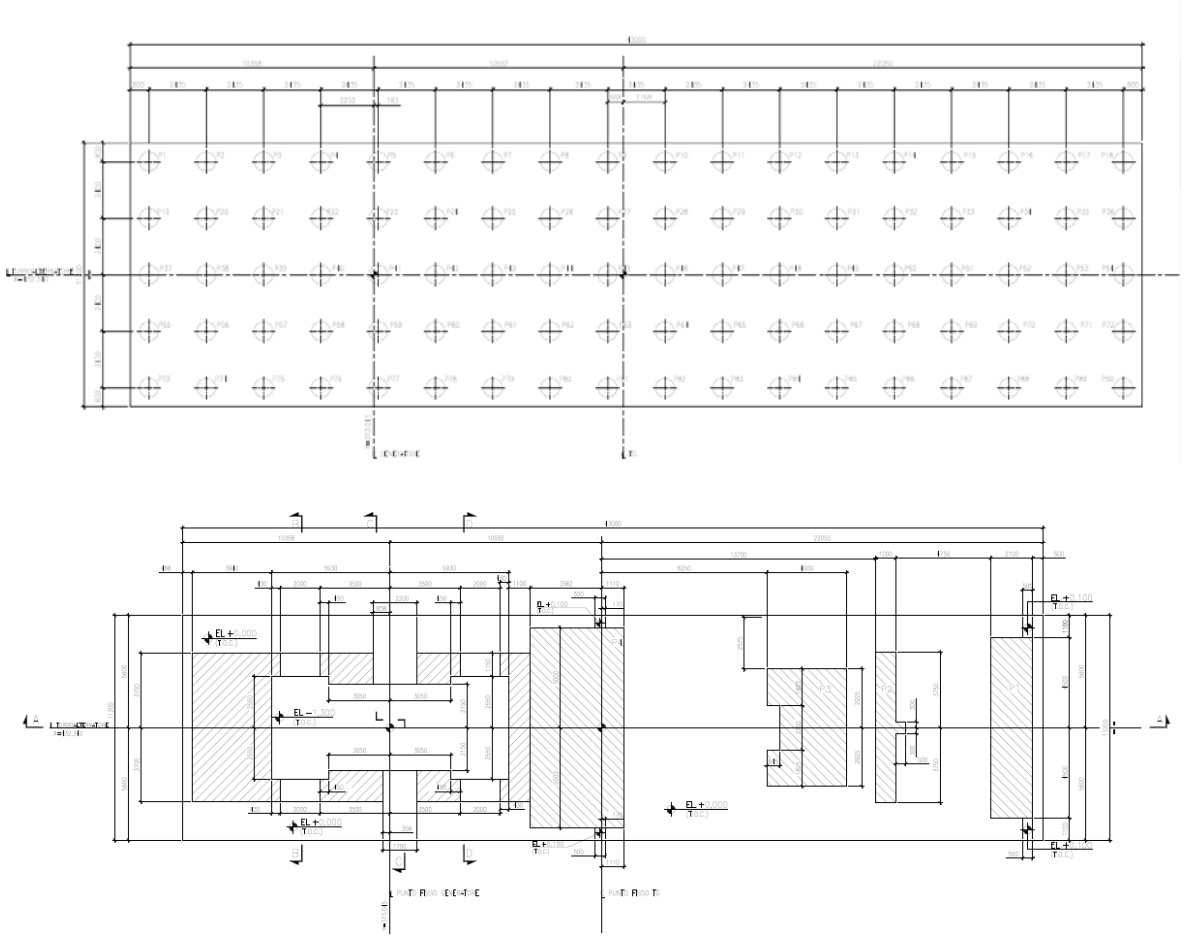
3.2 MODELLO STRUTTURALE

Le dimensioni in pianta degli elementi plate che simulano la fondazione sono pari a 0.5 m x 0.5 m. Lo spessore della platea è di 2,5m.

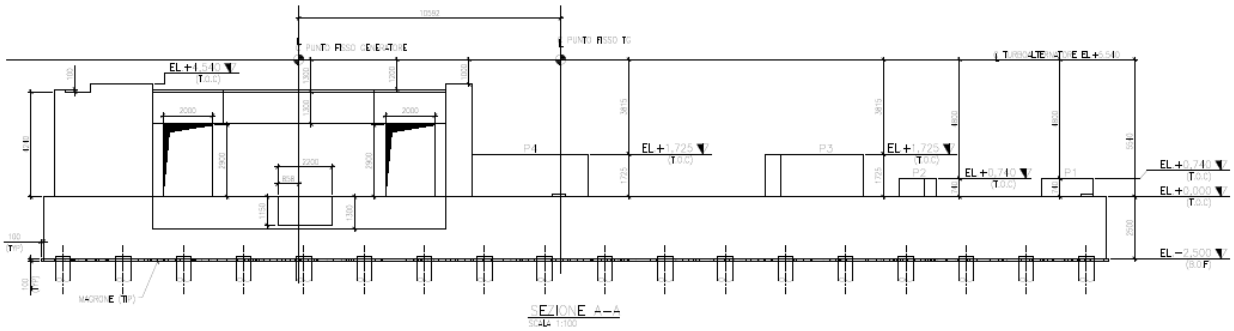


3D Modol in STAAD

La geometria della fondazione è indicata nei relativi elaborati grafici :

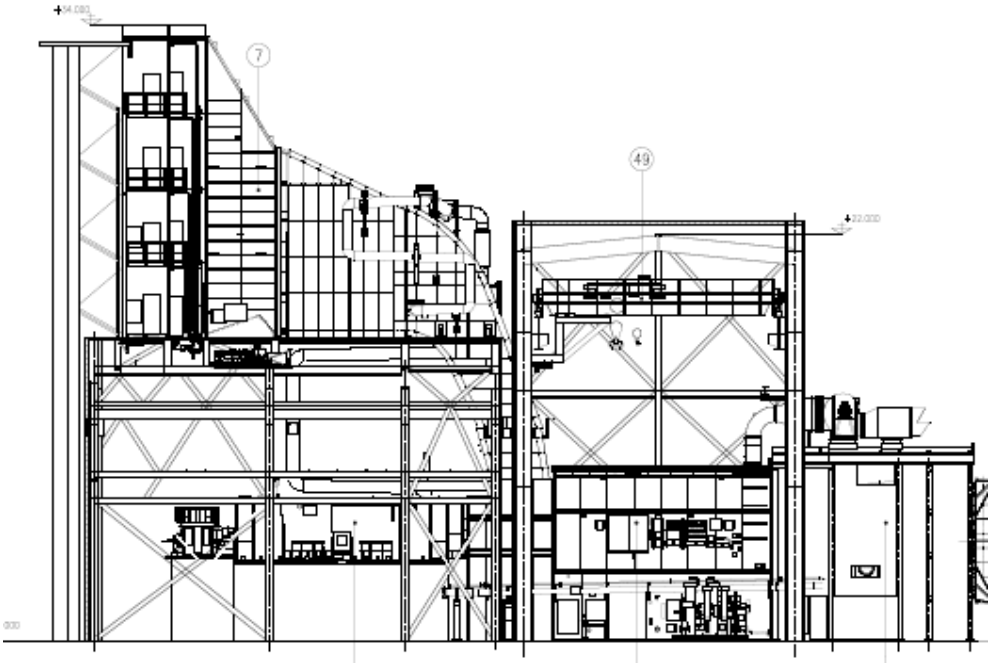


Dimensioni in pianta

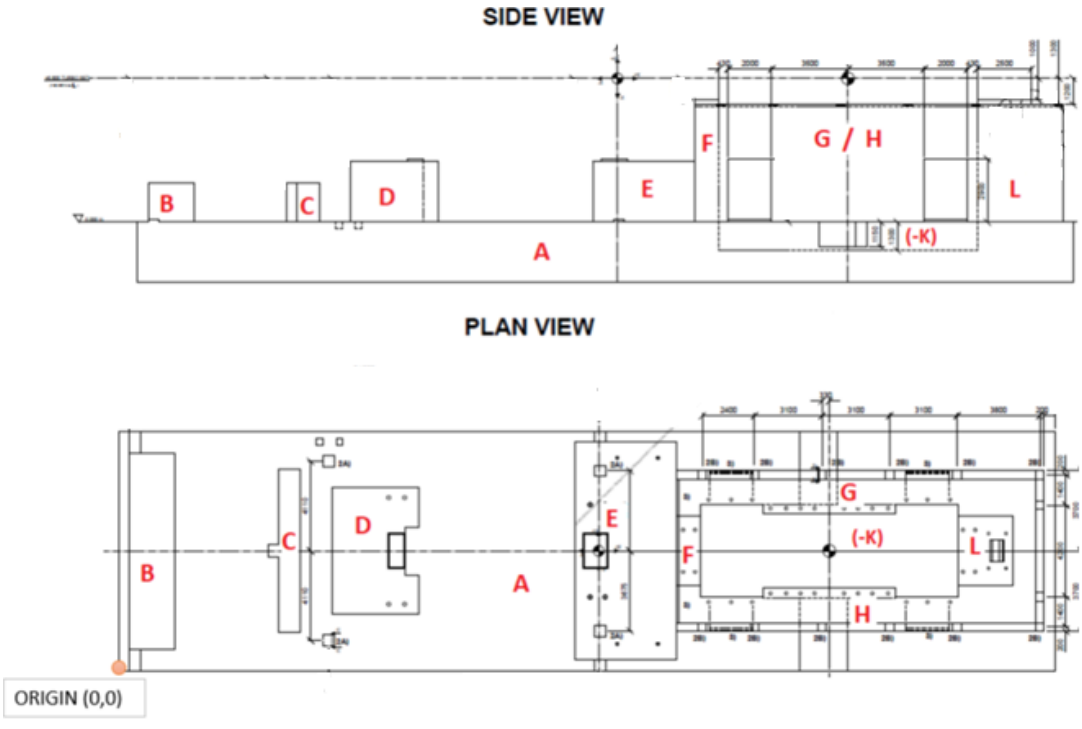


Sezione longitudinale

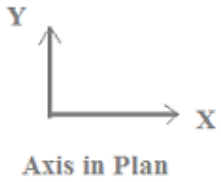
3.3 VERIFICA ECCENTRICITA' GEOEMTRICA E RAPPORTO TRA MASSE



Equipment Layout



Piante



Concrete density: $\gamma_{concrete} := 25\frac{kN}{m^3}$

Soil density: $\gamma_{soil} := 18\frac{kN}{m^3}$

Block 'A' details:

Length $A_{Length} := 43m$

Width c/c $A_{width} := 11.0m$

Height $A_{height} := 2.5m$

Weight $A_{weight} := A_{height} \cdot A_{width} \cdot A_{Length} \cdot \gamma_{concrete} = 29563 \cdot kN$

C.G of block from Origin in X Direction: $A_x := \frac{A_{Length}}{2} = 21.5\,m$

Block 'B' details:

Length $B_{Length} := 4.5m + 4.5m = 9\,m$

Width c/c $B_{width} := 2.1m$

Height $B_{height} := (6.6 - 4.8)m = 1.8\,m$

Weight $B_{weight} := B_{height} \cdot B_{width} \cdot B_{Length} \cdot \gamma_{concrete} = 850 \cdot kN$

C.G of block from Origin in X Direction: $B_x := 1.55m$

Block 'C' details:

Length $C_{Length} := 3.75m + 3.75m = 7.5\,m$

Width c/c $C_{width} := 1m$

Height $C_{height} := (6.6 - 4.8)m = 1.8\,m$

Weight $C_{weight} := C_{height} \cdot C_{width} \cdot C_{Length} \cdot \gamma_{concrete} = 337 \cdot kN$

C.G of block from Origin in X Direction: $C_x := 7.85m$

Block 'D' details:

Length $D_{Length} := 2.925m + 2.925m = 5.85\,m$

Width c/c $D_{width} := 4m$

Height $D_{height} := (6.6 - 3.815)m = 2.785\,m$

Weight $D_{weight} := D_{height} \cdot D_{width} \cdot D_{Length} \cdot \gamma_{concrete} = 1629 \cdot kN$

C.G of block from Origin in X Direction: $D_x := 12.91m$

Block 'E' details:

Length $E_{Length} := 10m$

Width c/c $E_{width} := 4.68m$

Height $E_{height} := (6.6 - 3.815)m = 2.785\,m$

Weight $E_{weight} := E_{height} \cdot E_{width} \cdot E_{Length} \cdot \gamma_{concrete} = 3258 \cdot kN$

C.G of block from Origin in X Direction: $E_x := 23.28m$

Block 'F' details:

Length $F_{Length} := 3.7m + 3.7m = 7.4\,m$

Width c/c $F_{width} := 1.1m$

Height $F_{height} := (6.6 - 1.2)m = 5.4\,m$

Weight $F_{weight} := F_{height} \cdot F_{width} \cdot F_{Length} \cdot \gamma_{concrete} = 1099 \cdot kN$

C.G of block from Origin in X Direction: $F_x := 26.165m$

Block 'G' details:

Length	$G_{Length} := 5.93m + 5.93m = 11.86\,m$
Width c/c	$G_{width} := 1.15m$
Height	$G_{height} := (6.6 - 1.2)m = 5.4\,m$
Weight	$G_{weight} := G_{height} \cdot G_{width} \cdot G_{Length} \cdot \gamma_{concrete} = 1841 \cdot kN$

C.G of block from Origin in X Direction: $G_x := 32.6m$

Block 'H' details:

Length	$H_{Length} := 5.93m + 5.93m = 11.86\,m$
Width c/c	$H_{width} := 1.15m$
Height	$H_{height} := (6.6 - 1.2)m = 5.4\,m$
Weight	$H_{weight} := H_{height} \cdot H_{width} \cdot H_{Length} \cdot \gamma_{concrete} = 1841 \cdot kN$

C.G of block from Origin in X Direction: $H_x := 32.6m$

Sump 'K' details:

Length $K_{Length} := 5.93m + 5.93m = 11.86\,m$

Width c/c $K_{width} := 5.1m$

Height $K_{height} := 1.3m$

Weight $K_{weight} := -K_{height} \cdot K_{width} \cdot K_{Length} \cdot \gamma_{concrete} = -1966 \cdot kN$

C.G of block from Origin in X Direction: $K_x := 32.m$

Block 'L' details:

Length $L_{Length} := 3.94m = 3.94\,m$

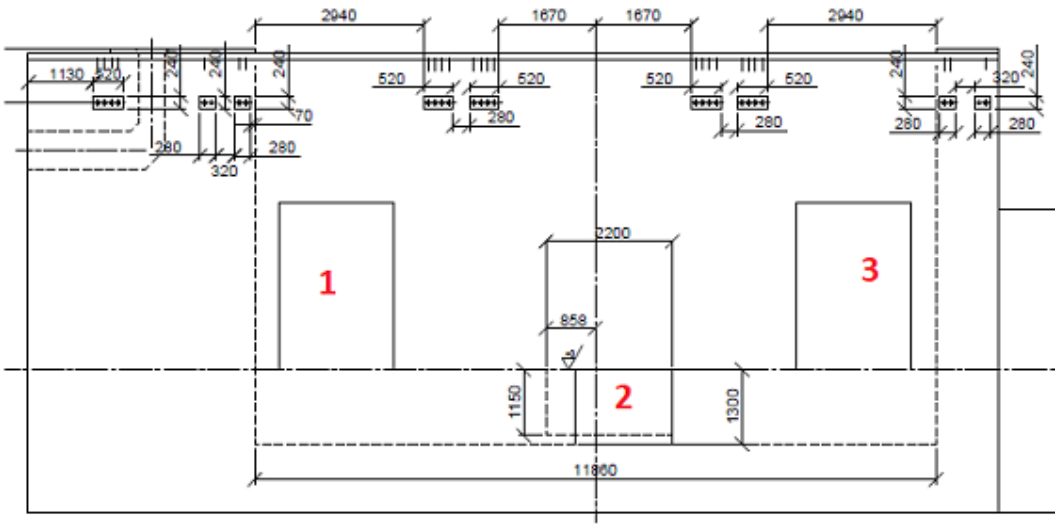
Width c/c $L_{width} := 7.4m$

Height $L_{height} := 5.4m$

Weight $L_{weight} := L_{height} \cdot L_{width} \cdot L_{Length} \cdot \gamma_{concrete} = 3936 \cdot kN$

C.G of block from Origin in X Direction: $L_x := 40.5m$

Openings:



Opening.1 Details:

Length $Open1_{Length} := 2m$

Width c/c $Open1_{width} := 1.15m$

Height $Open1_{height} := 2.9m$

Weight $Open1_{weight} := Open1_{Length} \cdot Open1_{width} \cdot Open1_{height} \cdot \gamma_{concrete} = 167 \cdot kN$

C.G of opening from Origin in X Direction: $Open1_x := 28.15m$

Opening.2 Details:

Length $Open2_{Length} := 2.2m$

Width c/c $Open2_{width} := 1.55m$

Height $Open2_{height} := 1.15m$

Weight $Open2_{weight} := Open2_{Length} \cdot Open2_{width} \cdot Open2_{height} \cdot \gamma_{concrete} = 98 \cdot kN$

C.G of opening from Origin in X Direction: $Open2_x := 31.84m$

Opening 3 Details:

Length $Open3_{Length} := 2m$

Width c/c $Open3_{width} := 1.15m$

Height $Open3_{height} := 2.9m$

Weight $Open3_{weight} := Open3_{Length} \cdot Open3_{width} \cdot Open3_{height} \cdot \gamma_{concrete} = 167 \cdot kN$

C.G of opening from Origin in X Direction: $Open3_x := 37.15m$

Weight of Machine:

Turbine:

Exhaust Diffuser: $EDG_{weight} := 937kN$

C.G of machine from Origin in X Direction: $EDG_x := 4.92m$

Thermal Block: $TB_{weight} := 6071kN$

C.G of machine from Origin in X Direction: $TB_x := 16.62m$

Air Intake Manifold: $AIM_{weight} := 378kN$

C.G of machine from Origin in X Direction: $AIM_x := 24.14m$

Generator: $Gen_{weight} := 4908kN$

C.G of machine from Origin in X Direction: $Gen_x := 32.63m$

Total Weight:

$$Weight_{Total} := A_{weight} + B_{weight} + C_{weight} + D_{weight} + E_{weight} + F_{weight} + G_{weight} \cdots + H_{weight} + K_{weight} + L_{weight} \cdots + EDG_{weight} + TB_{weight} + AIM_{weight} + Gen_{weight} \cdots + -2\left(Open1_{weight} + Open2_{weight} + Open3_{weight}\right)$$

$$Weight_{Total} = 53821 \cdot kN$$

$$Weight\_x\_CG_{summation} := A_{weight} \cdot A_x + B_{weight} \cdot B_x + C_{weight} \cdot C_x + D_{weight} \cdot D_x \cdots + E_{weight} \cdot E_x + F_{weight} \cdot F_x + G_{weight} \cdot G_x \cdots + H_{weight} \cdot H_x + K_{weight} \cdot K_x + L_{weight} \cdot L_x \cdots + EDG_{weight} \cdot EDG_x + TB_{weight} \cdot TB_x + AIM_{weight} \cdot AIM_x + Gen_{weight} \cdot Gen_x \cdots + -2\left(Open1_{weight} \cdot Open1_x + Open2_{weight} \cdot Open2_x + Open3_{weight} \cdot Open3_x\right)$$

$$Weight\_x\_CG_{summation} = 1.2 \times 10^{6} \cdot kN \cdot m$$

C.G of the entire Foundation+Machine:

$$CG\_x := \frac{Weight\_x\_CG_{summation}}{Weight_{Total}} = 22.826\,m$$

Eccentricity %

$$Pilecap_{length} := A_{Length}$$

$$e_x := \frac{\Delta x}{Pilecap_{length}} = 0.673 \cdot \%$$

Therefore, the eccentricity is with permissible limit of 3% in direction X.
There is no eccentricity in direction Y. Hence **OK**

Mass Ratio

Total Machine Weight: $Weight_{machine} := EDG_{weight} + TB_{weight} + AIM_{weight} + Gen_{weight}$

$$Weight_{machine} = 1.229 \times 10^4 \cdot kN$$

Weight of Foundation:

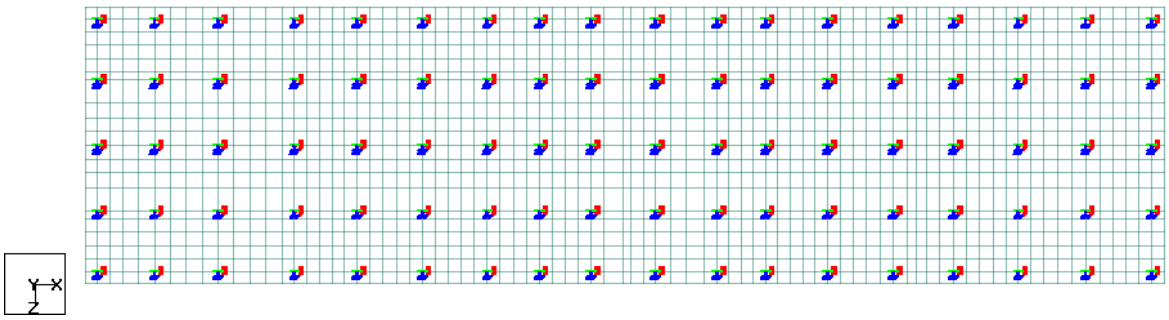
$$Weight_{Fdn} := A_{weight} + B_{weight} + C_{weight} + D_{weight} + E_{weight} + F_{weight} + G_{weight} \cdots + H_{weight} + K_{weight} + L_{weight} \cdots + -2\left(Open1_{weight} + Open2_{weight} + Open3_{weight}\right)$$

$$Mass_{Ratio} := \frac{Weight_{Fdn}}{Weight_{machine}} = 3.378$$

Therefore, the Mass Ratio > 3
Hence **OK**

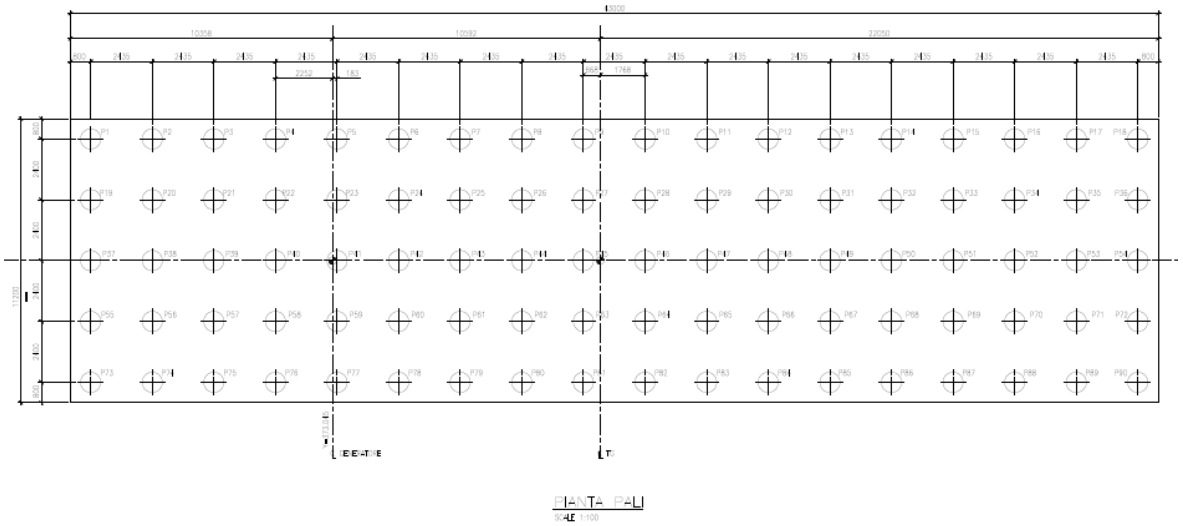
3.4 PROPRIETA' DINAMICHE DEL SUOLO E STIMA DEL MODULO DI TAGLIO DINAMICO (G')

I pali sono stati modellati in STAAD come molle ed I relativi valori di rigidezza sono stati calcolati come di seguito.



Disposizione pali

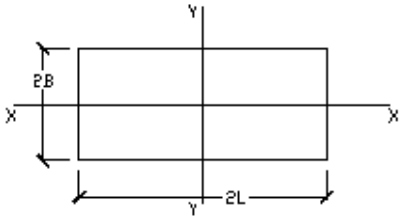
E' stata considerata la seguente disposizione, per un tot. di 90 pali.



$Mpa \equiv 10^6 Pa$ $kN \equiv 10^3 N$ $rpm \equiv \frac{Hz}{60}$ $kNm \equiv 10^3 N \cdot m$ $Mg := 10^3 \cdot kgf$

$Mg = 9.807 \cdot kN$

Geometrical data:



Length of Pile cap $L := 21.5m$ $2L = 43\,m$

Width of Pile Cap $B := 5.6m$ $2B = 11.2\,m$ $\frac{L}{B} = 3.839$

Height of Foundation $h := 2.5m$

Embedment into Soil $E := 3m$ $E = 3\,m$

Length of Pile $L_p := 20m$ Bottom of Pile, $L_{p\_bot} := 18m$

Size of Pile $D := 800mm$

Density of Pile $\gamma_{Pile} := 25 \frac{kN}{m^3}$ Poissons Ratio Pile $\mu_p := 0.15$

Soil properties:

Range of Depth:

$z := 16m$

Density of Soil along Depth:

$\gamma_{soil} := 1.8 \cdot \frac{Mg}{m^3}$

Considerata una categoria di suolo C, il valore della velocità dell'onda di taglio può essere assunta pari a 200 m/sec (si veda Tab. 3.3.2 di [1]).

Tab. 3.2.II – *Categorie di sottosuolo che permettono l'utilizzo dell'approccio semplificato.*

Categoria	Caratteristiche della superficie topografica
A	*Ammassi rocciosi affioranti o terreni molto rigidi* caratterizzati da valori di velocità delle onde di taglio superiori a 800 m/s, eventualmente comprendenti in superficie terreni di caratteristiche meccaniche più scadenti con spessore massimo pari a 3 m.
B	*Rocce tenere e depositi di terreni a grana grossa molto addensati o terreni a grana fina molto consistenti,* caratterizzati da un miglioramento delle proprietà meccaniche con la profondità e da valori di velocità equivalente compresi tra 360 m/s e 800 m/s.
C	*Depositi di terreni a grana grossa mediamente addensati o terreni a grana fina mediamente consistenti* con profondità del substrato superiori a 30 m, caratterizzati da un miglioramento delle proprietà meccaniche con la profondità e da valori di velocità equivalente compresi tra 180 m/s e 360 m/s.
D	*Depositi di terreni a grana grossa scarsamente addensati o di terreni a grana fina scarsamente consistenti,* con profondità del substrato superiori a 30 m, caratterizzati da un miglioramento delle proprietà meccaniche con la profondità e da valori di velocità equivalente compresi tra 100 e 180 m/s.
E	*Terreni con caratteristiche e valori di velocità equivalente riconducibili a quelle definite per le categorie C o D,* con profondità del substrato non superiore a 30 m.

Shear wave velocity of Soil: $v_s := 200 \cdot \frac{m}{s}$ For Soil type C

$G_z := \frac{\gamma_{soil}}{g} \cdot (v_s)^2$ $G_z = 72 \cdot MPa$

$G_d := G_z$ $G_d = 72 \cdot MPa$ Most expected value of Shear modulos of the soil in dynamic conditions

Average value of soil density and Poisson's Ratio over the study range considering depth of Pile at 20m:

$\mu_{soil} := 0.3$ ... assumed

$\gamma_{soil\_avg} := \gamma_{soil}$ $\gamma_{soil\_avg} = 17.7 \cdot \frac{kN}{m^3}$

$\mu_{soil\_avg} := \mu_{soil}$ $\mu_{soil\_avg} = 0.3$

Si riporta il calcolo della rigidezza del singolo palo secondo i metodi indicati nell'allegato D.

Calculation of Pile Stiffness as perNovak's Method:

[Ref. 1) Novak M., Dynamic Stiffness & Damping of Piles Can. Geotech. J. (See Appendix D)
2) Foundation Analysis and Design, 5th Ed. – Joseph E. Bowles

$i := 1..3$

Dynamic shear modulus value $G' := G_d = 72 \cdot MPa$

Range of values to be considered, $G := \left(\frac{G'}{1.5} \quad G' \quad 1.5G'\right)^T$

$\rho_{Soil\_avg} := \frac{\gamma_{soil\_avg}}{g} = 1.8 \cdot \frac{tonne}{m^3}$

$\rho_{Pile} := \frac{\gamma_{Pile}}{g} = 2.549 \cdot \frac{tonne}{m^3}$

$\frac{\rho_{Soil\_avg}}{\rho_{Pile}} = 0.706$

$A_p := \frac{\pi}{4} D^2$ $E_p := 27386 \frac{MN}{m^2}$ ... (Concrete Modulus)

$E_p = 27386 \cdot MPa$ $I_p := \frac{\pi}{64} \cdot D^4$ $I_p = 0.020106\, m^4$

Table 20-6 page 1129

$$s := \begin{pmatrix} 0.01 & 0.034 & 0.195 & -0.0181 & 0.0032 & 0.045 \\ 0.02 & 0.035 & 0.275 & -0.0362 & 0.009 & 0.072 \\ 0.03 & 0.037 & 0.337 & -0.0543 & 0.0166 & 0.105 \\ 0.04 & 0.040 & 0.389 & -0.0724 & 0.0256 & 0.139 \\ 0.05 & 0.044 & 0.435 & -0.0905 & 0.0358 & 0.174 \\ 0.06 & 0.049 & 0.448 & -0.114 & 0.05 & 0.208 \end{pmatrix}$$

Table 20-6 page 1129

$$\zeta := \begin{pmatrix} 0.01 & 0.002 & 0.136 & -0.028 & 0.008 & 0.002 \\ 0.02 & 0.007 & 0.198 & -0.056 & 0.023 & 0.007 \\ 0.03 & 0.016 & 0.245 & -0.084 & 0.043 & 0.01 \\ 0.04 & 0.027 & 0.283 & -0.112 & 0.066 & 0.015 \\ 0.05 & 0.041 & 0.314 & -0.141 & 0.092 & 0.019 \\ 0.06 & 0.055 & 0.346 & -0.169 & 0.122 & 0.22 \end{pmatrix}$$

Effective Radius of Pile

$$r_0 := \sqrt{\frac{A_p}{\pi}} = 0.4\,m \qquad \frac{L_p}{r_0} = 37.5$$

$$Check_1 := \begin{cases} \text{"OK"} & \text{if } \frac{L_p}{r_0} > 30 \\ \text{"Revise"} & \text{otherwise} \end{cases}$$

$Check_1 = \text{"OK"}$

$$V_{s_i} := \sqrt{\frac{G_i}{\rho_{Soil\_avg}}} \qquad V_s = \begin{pmatrix} 163.299 \\ 200 \\ 244.949 \end{pmatrix} \frac{m}{s}$$

$$V_p := \sqrt{\frac{E_p}{\rho_{Pile}}} \qquad V_p = 3277.59\,\frac{m}{s}$$

$I_{xx} := I_p = 0.02011\,m^4$ $\qquad I_{yy} := I_p = 0.02\,m^4$

$$Ra_i := \left(\frac{V_{s_i}}{V_p}\right) \qquad Ra = \begin{pmatrix} 0.049823 \\ 0.06102 \\ 0.074734 \end{pmatrix}$$

$J := I_{xx} + I_{xx} = 0.04\,m^4$

Machine Parameters:

Operating speed of the machine, $f_o := 3000rpm$ $f_o = 50 \cdot Hz$

Circular frequency, $\omega_o := f_o \cdot 2 \cdot \pi = 314.159 \cdot \frac{rad}{sec}$

The dimensionless frequency parameter for rectangular base, $a_{0_i} := \left(\frac{\omega_o \cdot r_0}{V_{s_i}} \right)$

$$a_0 = \begin{pmatrix} 0.77 \\ 0.628 \\ 0.513 \end{pmatrix}$$

Comment: a_0 should be ranged between 0 and 1.5. For a_0 to exceed 1.5, one would have a very high speed machine and /or a small ground shear wave velocity. In these cases, some kind of soil strengthening or the use of piles may be necessary if vibration control is critical.

Vertical Springs

$$K_{z_i} := \frac{E_p \cdot A_p}{r_0} \cdot linterp\left(s^{\langle 1 \rangle}, s^{\langle 2 \rangle}, Ra_i \right)$$

$$K_z = \begin{pmatrix} 1511.791 \\ 1703.858 \\ 1939.837 \end{pmatrix} \frac{1}{m} \cdot MN$$

$$c_{z_i} := \frac{E_p \cdot A_p}{V_{s_i}} \cdot linterp\left(\zeta^{\langle 1 \rangle}, \zeta^{\langle 2 \rangle}, Ra_i \right)$$

$$c_z = \begin{pmatrix} 3.435 \\ 3.884 \\ 4.25 \end{pmatrix} s \cdot \frac{MN}{m}$$

Horizontal Springs

$$K_{h_i} := \frac{E_p \cdot I_p}{(r_0)^3} \cdot \text{linterp}\left(s^{\langle 1 \rangle}, s^{\langle 5 \rangle}, Ra_i\right)$$

$$K_h = \begin{pmatrix} 306.454 \\ 442.645 \\ 610.19 \end{pmatrix} \frac{1}{m} \cdot MN$$

$$c_{h_i} := \frac{E_p \cdot I_p}{V_{s_i} \cdot r_0^{\,2}} \cdot \text{linterp}\left(\zeta^{\langle 1 \rangle}, \zeta^{\langle 5 \rangle}, Ra_i\right)$$

$$c_h = \begin{pmatrix} 1.929 \\ 2.152 \\ 2.335 \end{pmatrix} \frac{s}{m} \cdot MN$$

Rocking

$$K_{\theta_i} := \left(\frac{E_p \cdot I_p}{r_0} \cdot \frac{1}{rad}\right) \cdot \text{linterp}\left(s^{\langle 1 \rangle}, s^{\langle 3 \rangle}, Ra_i\right)$$

$$K_\theta = \begin{pmatrix} 597.687 \\ 618.53 \\ 643.072 \end{pmatrix} \cdot MN \cdot \frac{m}{rad}$$

$$c_{\theta_i} := \frac{E_p \cdot I_{xx}}{V_{s_i}} \cdot \text{linterp}\left(\zeta^{\langle 1 \rangle}, \zeta^{\langle 3 \rangle}, Ra_i\right)$$

$$c_\theta = \begin{pmatrix} 1.057 \\ 0.962 \\ 0.884 \end{pmatrix} s \cdot m \cdot MN$$

Torsion

$$G_p := \frac{E_p}{2(1+\mu_p)} = 1.191 \times 10^4 \cdot MPa$$

$$K_{t_i} := \left(\frac{G_p \cdot J}{r_0}\right) \cdot linterp\left(s^{\langle 1 \rangle}, s^{\langle 6 \rangle}, Ra_i\right)$$

$$K_t = \begin{pmatrix} 207.539 \\ 253.133 \\ 308.947 \end{pmatrix} m \cdot MN$$

$$C_{t_i} := \left(\frac{G_p \cdot J}{V_{s_i}}\right) \cdot linterp\left(\zeta^{\langle 1 \rangle}, \zeta^{\langle 6 \rangle}, Ra_i\right)$$

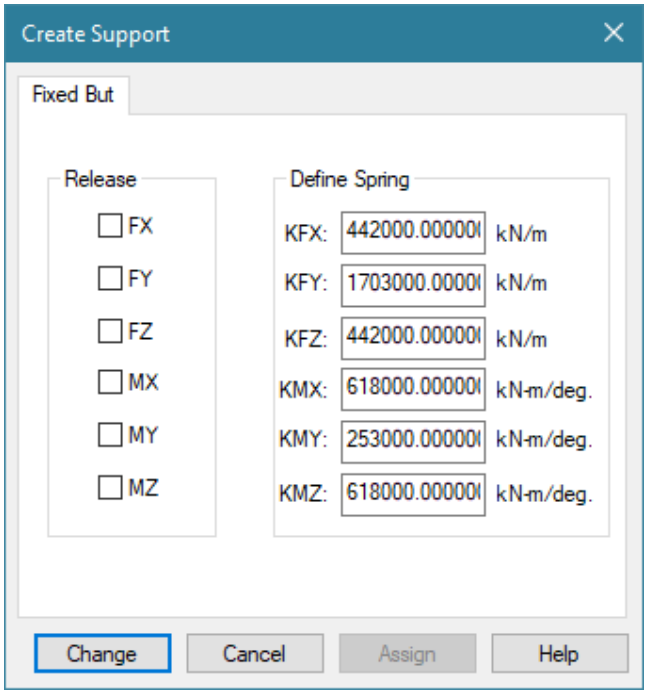
$$C_t = \begin{pmatrix} 0.0555 \\ 0.57579 \\ 1.00896 \end{pmatrix} s \cdot m \cdot MN$$

Cross Stiffness

$$K_{x\theta_i} := \left(\frac{E_p \cdot I_p}{r_0^{\,2}}\right) \cdot linterp\left(s^{\langle 1 \rangle}, s^{\langle 4 \rangle}, Ra_i\right)$$

$$K_{x\theta} = \begin{pmatrix} -310.346 \\ -400.575 \\ -511.485 \end{pmatrix} \cdot MN$$

$$C_{x\theta_i} := \left[\frac{E_p \cdot I_p}{(r_0 \cdot V_s)_i}\right] \cdot linterp\left(\zeta^{\langle 1 \rangle}, \zeta^{\langle 4 \rangle}, Ra_i\right)$$



3.5 ANALISI STATICA

Lo scopo di tale analisi è quella di verificare la capacità portante dei pali agli SLU e di controllare il livello deformativo della Fondazione agli SLE, considerando le diverse condizioni di carico.

3.6 ANALISI DINAMICA

Lo scopo di tale analisi è quella di determinare la frequenza della struttura e di comparala con quella della macchina.

L'analisi delle vibrazioni e il controllo delle forzanti dovrà essere sviluppato in fase esecutiva una volta noti i dati del Vendor della macchina scelta.

4 CARICHI CARATTERISTICI E COMBINAZIONI DI CARICO

4.1 CARICHI CARATTERISTICI

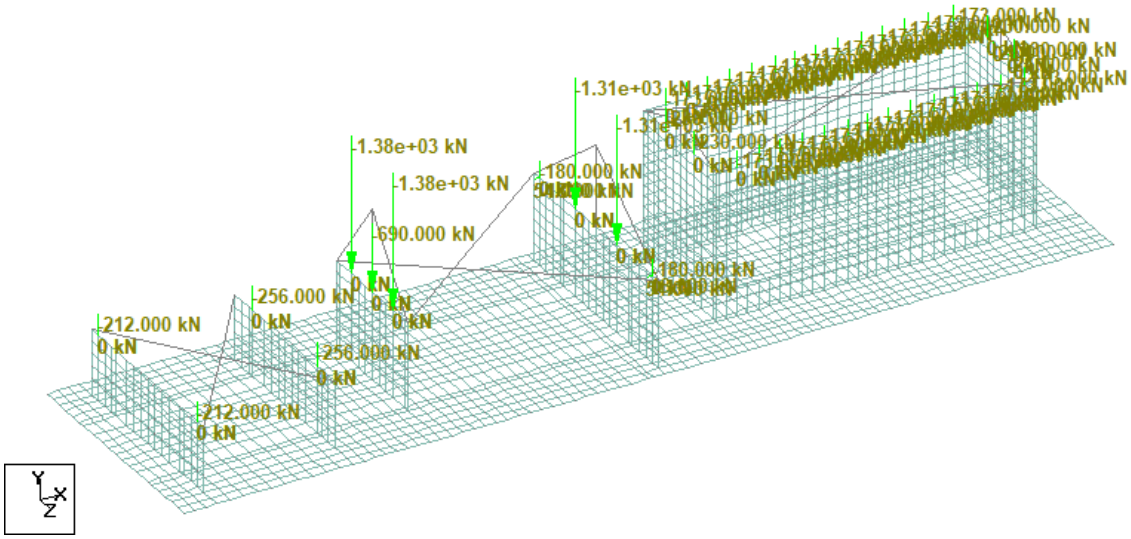
4.1.1 CARICHI PERMANENTI

Sono inclusi:

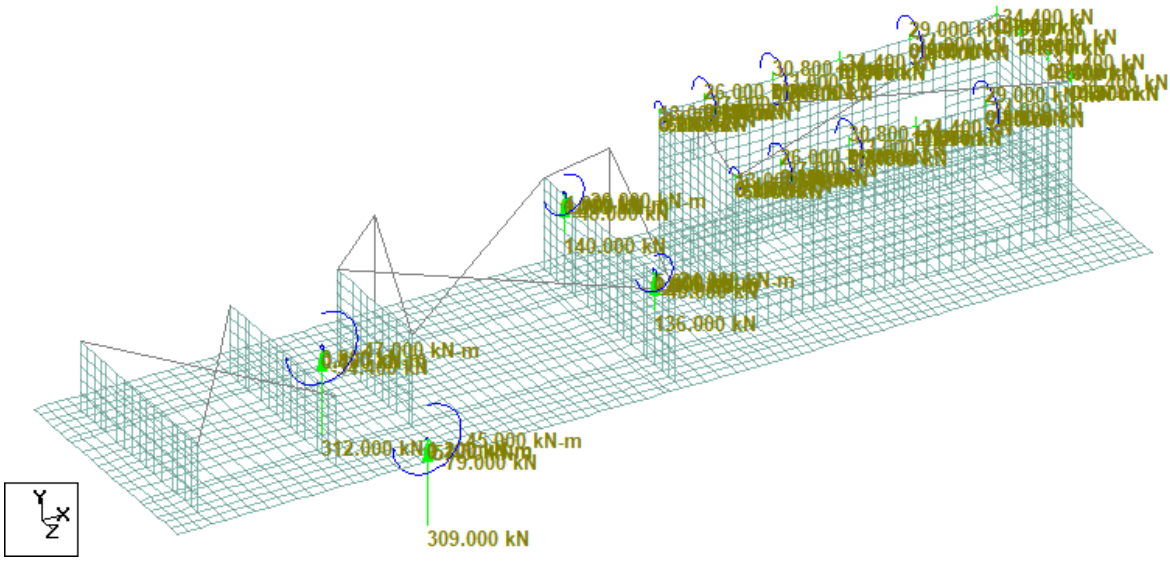
- Peso proprio Fondazione.

4.1.2 CARICHI PERMANENTI DA VENDOR

I carichi statici dati dal Vendor sono stati sommati e applicati nei CG dei diversi componenti della macchina.



Carichi macchina

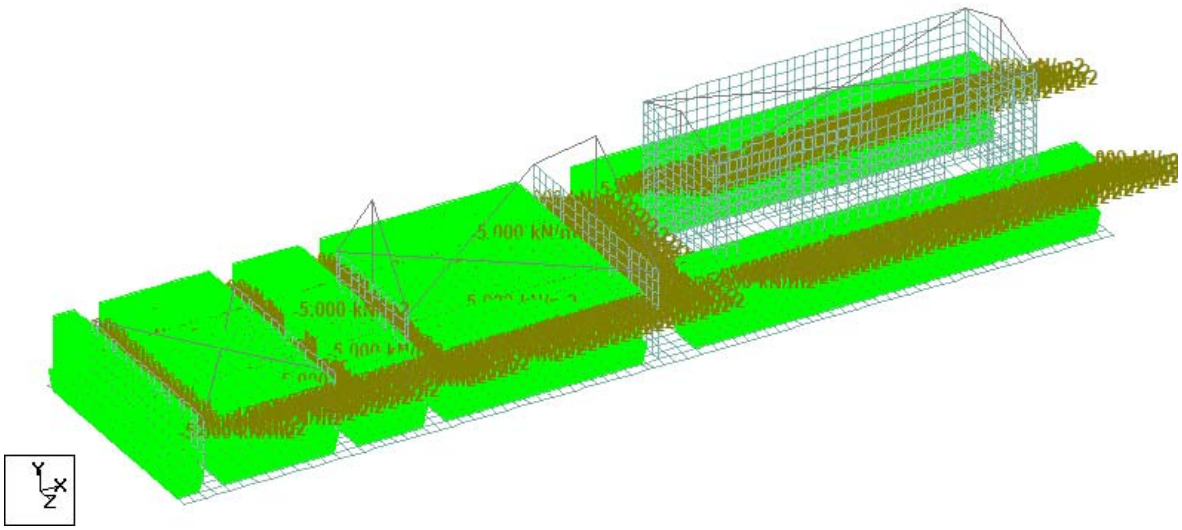


Peso cabinato esterno

4.1.3 **CARICHI VARIABILI**

Sono inclusi:

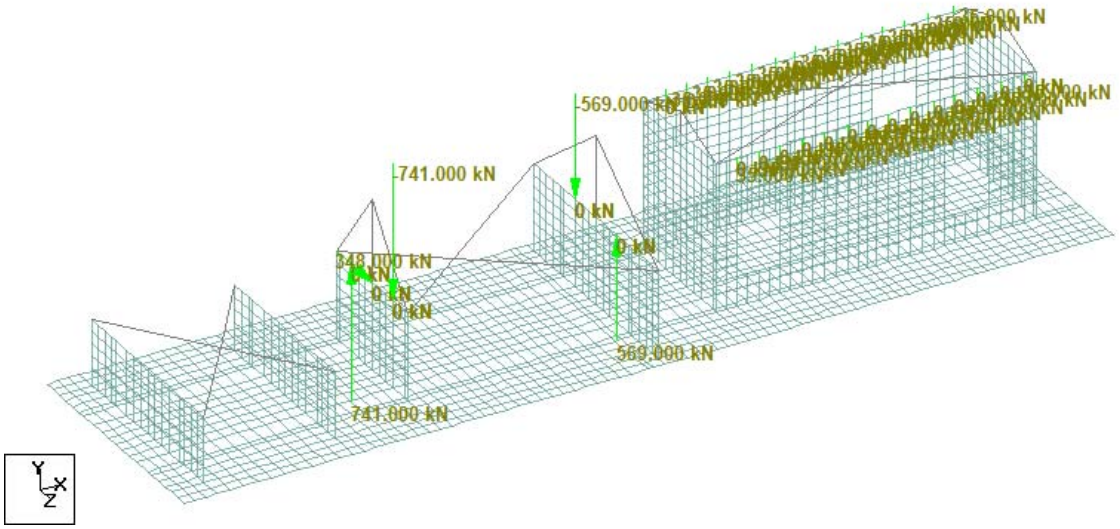
- Sovraccarico di 5kN/m^2 applicato sull'estradosso della fondazione.



Carico variabile

4.1.4 **CARICHI OPERATIVI**

- Torque Load, come da dati del vendor (si veda Allegato A).



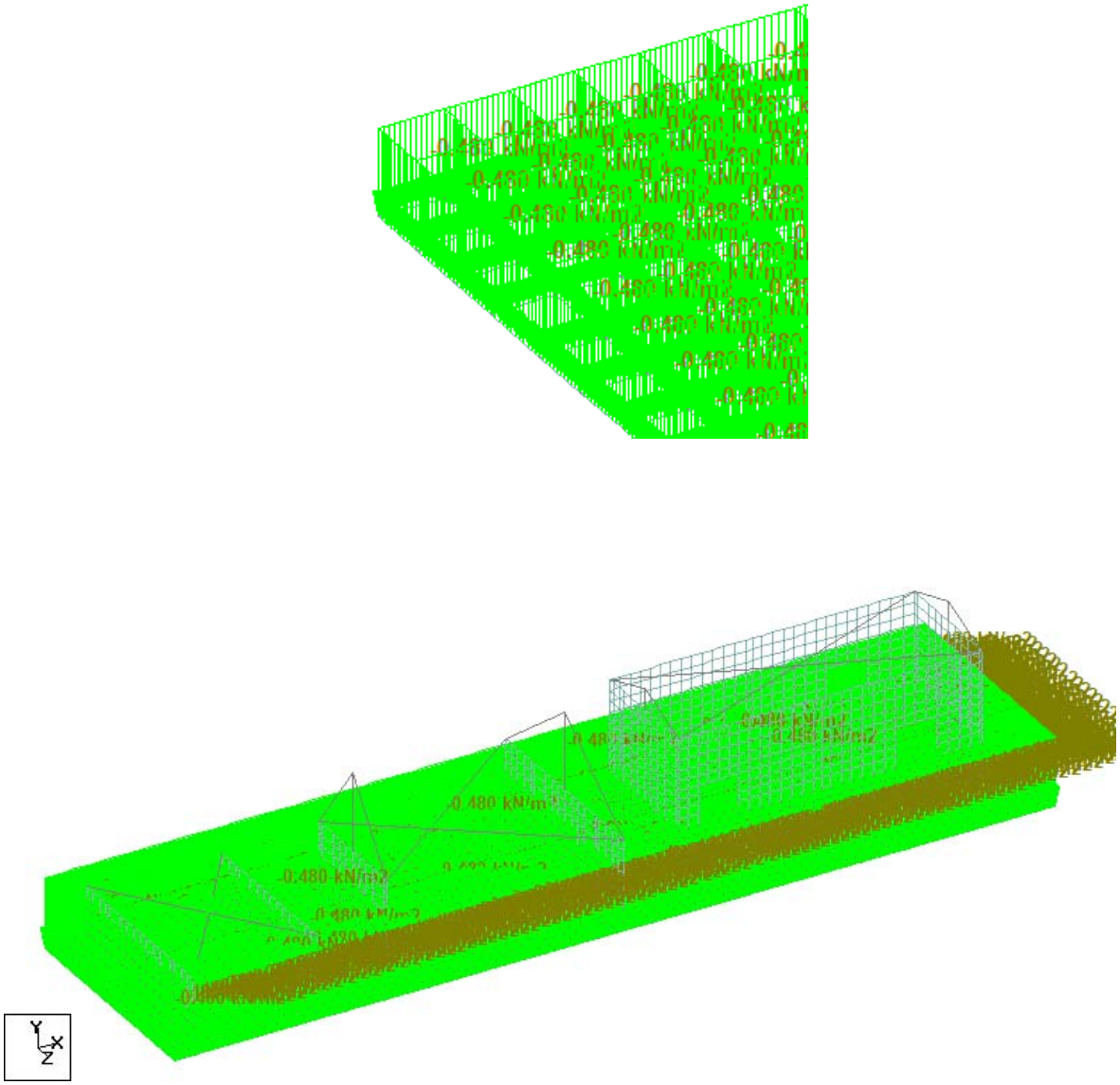
Torque Load

4.1.5 **AZIONE DEL VENTO, X E Z**

Dal momento che la massa della struttura è molto alta e che la sua altezza rimane esigua, tali forze non sono governanti al fine della progettazione.

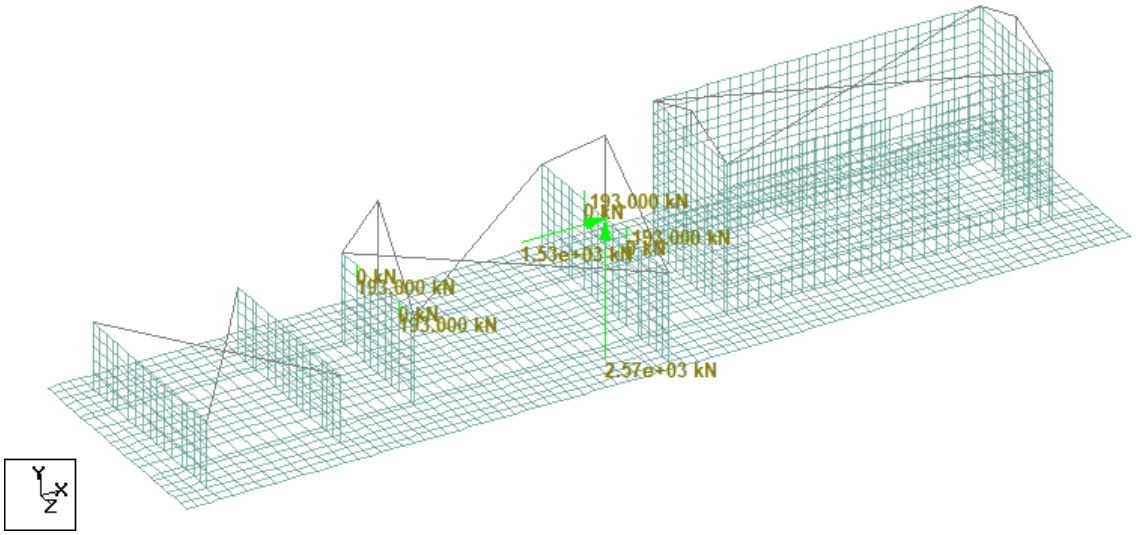
4.1.6 **AZIONE DA NEVE**

- Azione di 0.48kN/m2 applicato sull'estradosso della fondazione.

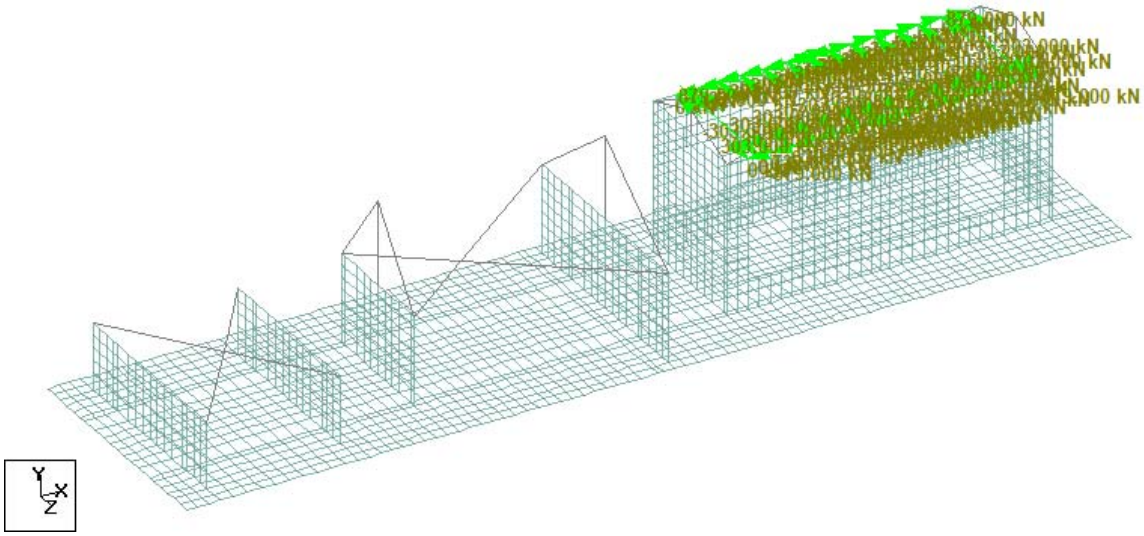


Azione da neve

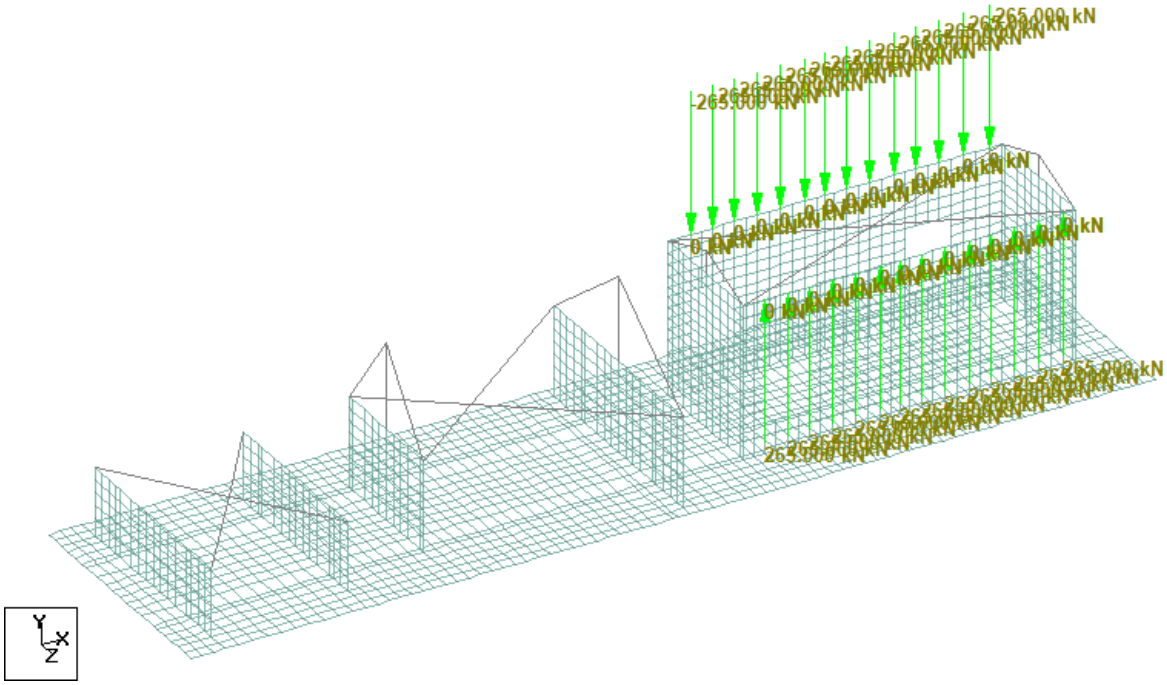
4.1.7 **DEFLAGRATION**



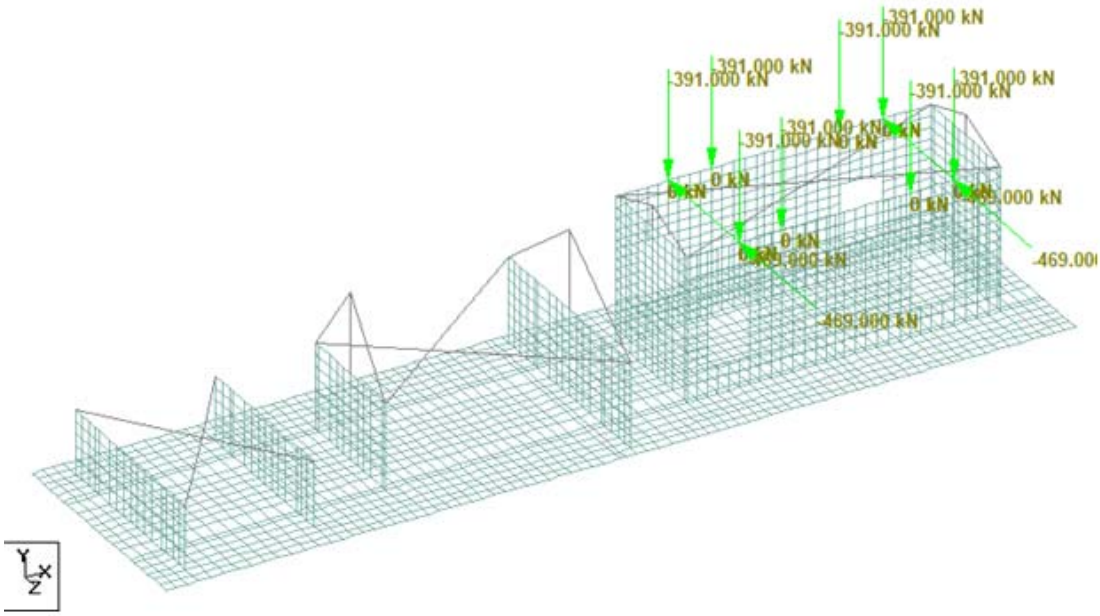
4.1.8 **TEMPERATURA**



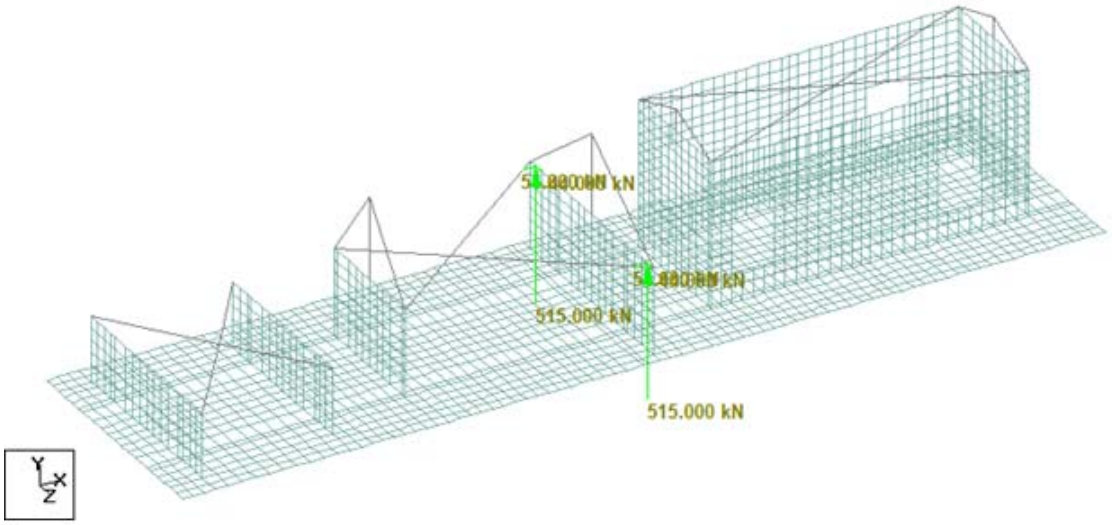
4.1.9 **SHORT CIRCUIT LOAD**



4.1.10 **STATOR ALIGNMENT**

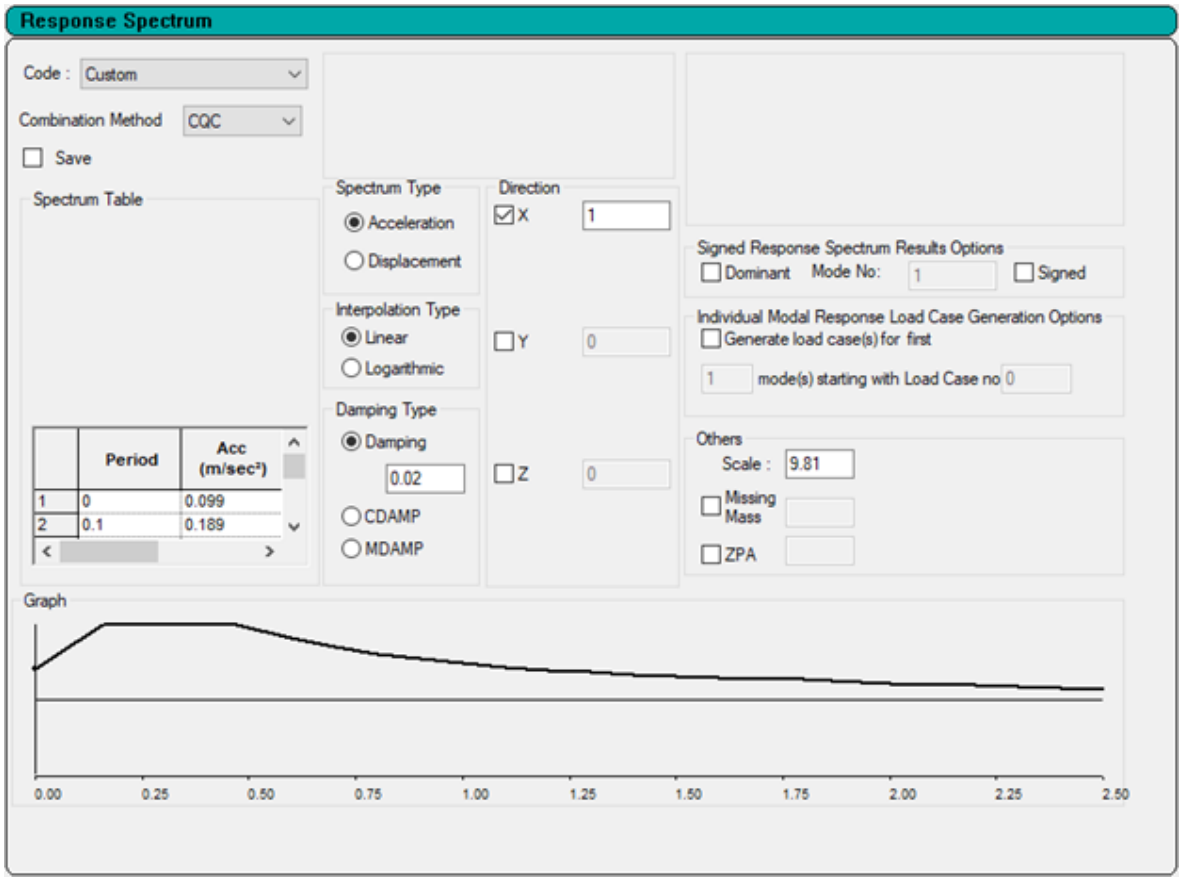


4.1.11 **SURGE**



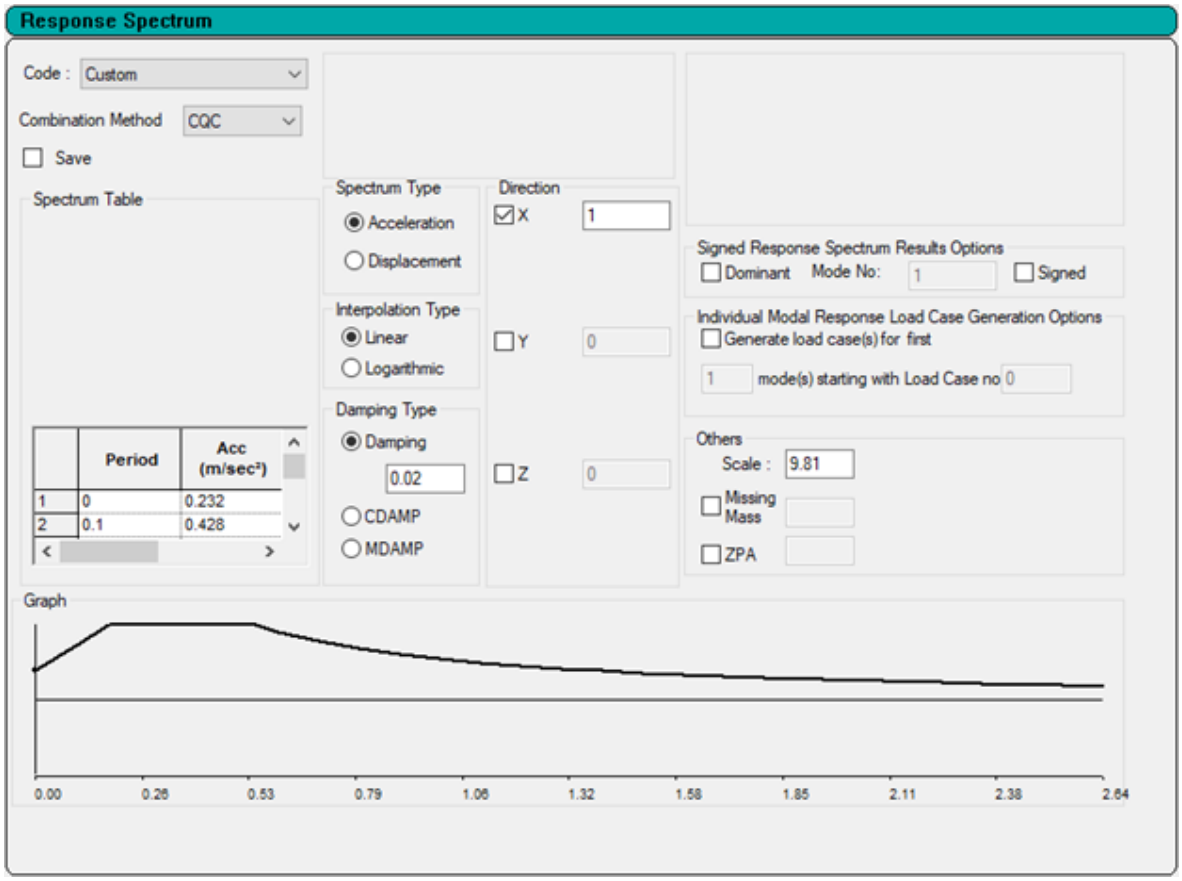
4.1.12 **AZIONE SISMICA (E)**

SLD



Sono state calcolate le forze statiche equivalenti considerando il picco dello spettro (0.24g).

SLV (q = 1.5)



Sono state calcolate le forze statiche equivalenti considerando il picco dello spettro (0.586g).

4.2 CASI DI CARICO

LOAD 1 LOADTYPE Dead TITLE DEAD_STRUCTURE

LOAD 2 LOADTYPE Dead TITLE DEAD_MACHINE

LOAD 3 LOADTYPE Live TITLE LIVE_LOAD

LOAD 4 LOADTYPE None TITLE OPERATING_TORQUE

LOAD 5 LOADTYPE Wind TITLE WIND_X

LOAD 6 LOADTYPE Wind TITLE WIND_Y

LOAD 7 LOADTYPE Temperature TITLE TEMPERATURE_+

LOAD 8 LOADTYPE Temperature TITLE TEMPERATURE_-

LOAD 9 LOADTYPE Snow TITLE SNOW_LOAD

LOAD 10 LOADTYPE None TITLE EMERGENCY_LOAD

LOAD 18 LOADTYPE None TITLE EARTHQUAKE_X SLD

LOAD 19 LOADTYPE None TITLE EARTHQUAKE_Z SLD

LOAD 20 LOADTYPE None TITLE EARTHQUAKE_X SLV

LOAD 21 LOADTYPE None TITLE EARTHQUAKE_Z SLV

LOAD 22 LOADTYPE None TITLE DEFLAGRATION

LOAD 23 LOADTYPE None TITLE SHORT_CIRCUIT

LOAD 35 LOADTYPE None TITLE SERVICE LOAD

LOAD 36 LOADTYPE None TITLE STATOR ALIGNMENT

LOAD 37 LOADTYPE None TITLE SURGE

4.3 COMBINAZIONI DI CARICO

Sono state considerate le seguenti combinazioni:

2.5.3. COMBINAZIONI DELLE AZIONI

Ai fini delle verifiche degli stati limite, si definiscono le seguenti combinazioni delle azioni.

- Combinazione fondamentale, generalmente impiegata per gli stati limite ultimi (SLU):
  $\gamma_{G1} \cdot G_1 + \gamma_{G2} \cdot G_2 + \gamma_P \cdot P + \gamma_{Q1} \cdot Q_{k1} + \gamma_{Q2} \cdot \psi_{02} \cdot Q_{k2} + \gamma_{Q3} \cdot \psi_{03} \cdot Q_{k3} + \ldots$ [2.5.1]
- Combinazione caratteristica, cosiddetta rara, generalmente impiegata per gli stati limite di esercizio (SLE) irreversibili:
  $G_1 + G_2 + P + Q_{k1} + \psi_{02} \cdot Q_{k2} + \psi_{03} \cdot Q_{k3} + \ldots$ [2.5.2]
- Combinazione frequente, generalmente impiegata per gli stati limite di esercizio (SLE) reversibili:
  $G_1 + G_2 + P + \psi_{11} \cdot Q_{k1} + \psi_{22} \cdot Q_{k2} + \psi_{23} \cdot Q_{k3} + \ldots$ [2.5.3]
- Combinazione quasi permanente (SLE), generalmente impiegata per gli effetti a lungo termine:
  $G_1 + G_2 + P + \psi_{21} \cdot Q_{k1} + \psi_{22} \cdot Q_{k2} + \psi_{23} \cdot Q_{k3} + \ldots$ [2.5.4]
- Combinazione sismica, impiegata per gli stati limite ultimi e di esercizio connessi all'azione sismica E:
  $E + G_1 + G_2 + P + \psi_{21} \cdot Q_{k1} + \psi_{22} \cdot Q_{k2} + \ldots$ [2.5.5]
- Combinazione eccezionale, impiegata per gli stati limite ultimi connessi alle azioni eccezionali A:
  $G_1 + G_2 + P + A_d + \psi_{21} \cdot Q_{k1} + \psi_{22} \cdot Q_{k2} + \ldots$ [2.5.6]

Gli effetti dell'azione sismica saranno valutati tenendo conto delle masse associate ai seguenti carichi gravitazionali:

$$G_1 + G_2 + \sum_j \psi_{2j} Q_{kj} \,. \qquad [2.5.7]$$

Nelle combinazioni si intende che vengano omessi i carichi Q_{kj} che danno un contributo favorevole ai fini delle verifiche e, se del caso, i carichi G_2.

Altre combinazioni sono da considerare in funzione di specifici aspetti (p. es. fatica, ecc.).

Nelle formule sopra riportate il simbolo *"+"* vuol dire *"combinato con"*.

I valori dei coefficienti ψ_{0j}, ψ_{1j} e ψ_{2j} sono dati nella Tab. 2.5.I oppure nella Tab. 5.1.VI per i ponti stradali e nella Tab. 5.2.VII per i ponti ferroviari. I valori dei coefficienti parziali di sicurezza γ_{Gi} e γ_{Qj} sono dati nel § 2.6.1.

Con riferimento alla durata relativa ai livelli di intensità di un'azione variabile, si definiscono:

- valore quasi permanente $\psi_{2j} \cdot Q_{kj}$: il valore istantaneo superato oltre il 50% del tempo nel periodo di riferimento. Indicativamente, esso può assumersi uguale alla media della distribuzione temporale dell'intensità;
- valore frequente $\psi_{1j} \cdot Q_{kj}$: il valore superato per un periodo totale di tempo che rappresenti una piccola frazione del periodo di riferimento. Indicativamente, esso può assumersi uguale al frattile 95% della distribuzione temporale dell'intensità;
- valore di combinazione $\psi_{0j} \cdot Q_{kj}$: il valore tale che la probabilità di superamento degli effetti causati dalla concomitanza con altre azioni sia circa la stessa di quella associata al valore caratteristico di una singola azione.

Nel caso in cui la caratterizzazione probabilistica dell'azione considerata non sia disponibile, ad essa può essere attribuito il valore nominale. Nel seguito sono indicati con pedice k i valori caratteristici; senza pedice k i valori nominali.

La Tab. 2.5.I riporta i coefficienti di combinazione da adottarsi per gli edifici civili e industriali di tipo corrente.

Tab. 2.5.I – *Valori dei coefficienti di combinazione*

Categoria/Azione variabile	ψ_{0j}	ψ_{1j}	ψ_{2j}
Categoria A - Ambienti ad uso residenziale	0,7	0,5	0,3
Categoria B - Uffici	0,7	0,5	0,3
Categoria C - Ambienti suscettibili di affollamento	0,7	0,7	0,6
Categoria D - Ambienti ad uso commerciale	0,7	0,7	0,6
Categoria E – Aree per immagazzinamento, uso commerciale e uso industriale Biblioteche, archivi, magazzini e ambienti ad uso industriale	1,0	0,9	0,8
Categoria F - Rimesse , parcheggi ed aree per il traffico di veicoli (per autoveicoli di peso ≤ 30 kN)	0,7	0,7	0,6

Categoria G – Rimesse, parcheggi ed aree per il traffico di veicoli (per autoveicoli di peso > 30 kN)	0,7	0,5	0,3
Categoria H - Coperture accessibili per sola manutenzione	0,0	0,0	0,0
Categoria I – Coperture praticabili	da valutarsi caso per caso		
Categoria K – Coperture per usi speciali (impianti, eliporti, ...)			
Vento	0,6	0,2	0,0
Neve (a quota ≤ 1000 m s.l.m.)	0,5	0,2	0,0
Neve (a quota > 1000 m s.l.m.)	0,7	0,5	0,2
Variazioni termiche	0,6	0,5	0,0

2.6. AZIONI NELLE VERIFICHE AGLI STATI LIMITE

Le verifiche agli stati limite devono essere eseguite per tutte le più gravose condizioni di carico che possono agire sulla struttura, valutando gli effetti delle combinazioni definite nel § 2.5.3.

2.6.1. STATI LIMITE ULTIMI

Nelle verifiche agli stati limite ultimi si distinguono:

– lo stato limite di equilibrio come corpo rigido: **EQU**

– lo stato limite di resistenza della struttura compresi gli elementi di fondazione: **STR**

– lo stato limite di resistenza del terreno: **GEO**

Fatte salve tutte le prescrizioni fornite nei capitoli successivi delle presenti norme, la Tab. 2.6.I riporta i valori dei coefficienti parziali γ_F da assumersi per la determinazione degli effetti delle azioni nelle verifiche agli stati limite ultimi.

Per le verifiche nei confronti dello stato limite ultimo di equilibrio come corpo rigido (EQU) si utilizzano i coefficienti γ_F riportati nella colonna EQU della Tabella 2.6.I.

Per la progettazione di componenti strutturali che non coinvolgano azioni di tipo geotecnico, le verifiche nei confronti degli stati limite ultimi strutturali (STR) si eseguono adottando i coefficienti γ_F riportati nella colonna A1 della Tabella 2.6.I.

Per la progettazione di elementi strutturali che coinvolgano azioni di tipo geotecnico (plinti, platee, pali, muri di sostegno, ...) le verifiche nei confronti degli stati limite ultimi strutturali (STR) e geotecnici (GEO) si eseguono adottando due possibili approcci progettuali, fra loro alternativi.

Nell'*Approccio 1*, le verifiche si conducono con due diverse combinazioni di gruppi di coefficienti parziali, rispettivamente definiti per le azioni (γ_F), per la resistenza dei materiali (γ_M) e, eventualmente, per la resistenza globale del sistema (γ_R). Nella *Combinazione 1* dell'*Approccio 1*, per le azioni si impiegano i coefficienti γ_F riportati nella colonna A1 della Tabella 2.6.I. Nella *Combinazione 2* dell'*Approccio 1*, si impiegano invece i coefficienti γ_F riportati nella colonna A2. In tutti i casi, sia nei confronti del dimensionamento strutturale, sia per quello geotecnico, si deve utilizzare la combinazione più gravosa fra le due precedenti.

Nell'*Approccio 2* si impiega un'unica combinazione dei gruppi di coefficienti parziali definiti per le Azioni (γ_F), per la resistenza dei materiali (γ_M) e, eventualmente, per la resistenza globale (γ_R). In tale approccio, per le azioni si impiegano i coefficienti γ_F riportati nella colonna A1.

I coefficienti γ_M e γ_R sono definiti nei capitoli successivi.

Tab. 2.6.I – *Coefficienti parziali per le azioni o per l'effetto delle azioni nelle verifiche SLU*

		Coefficiente γ_F	EQU	A1	A2
Carichi permanenti G_1	Favorevoli	γ_{G1}	0,9	1,0	1,0
	Sfavorevoli		1,1	1,3	1,0
Carichi permanenti non strutturali G_2[(1)]	Favorevoli	γ_{G2}	0,8	0,8	0,8
	Sfavorevoli		1,5	1,5	1,3
Azioni variabili Q	Favorevoli	γ_{Qi}	0,0	0,0	0,0
	Sfavorevoli		1,5	1,5	1,3

[(1)] Nel caso in cui l'intensità dei carichi permanenti non strutturali o di una parte di essi (ad es. carichi permanenti portati) sia ben definita in fase di progetto, per detti carichi o per la parte di essi nota si potranno adottare gli stessi coefficienti parziali validi per le azioni permanenti.

5 ANALISI MODALE

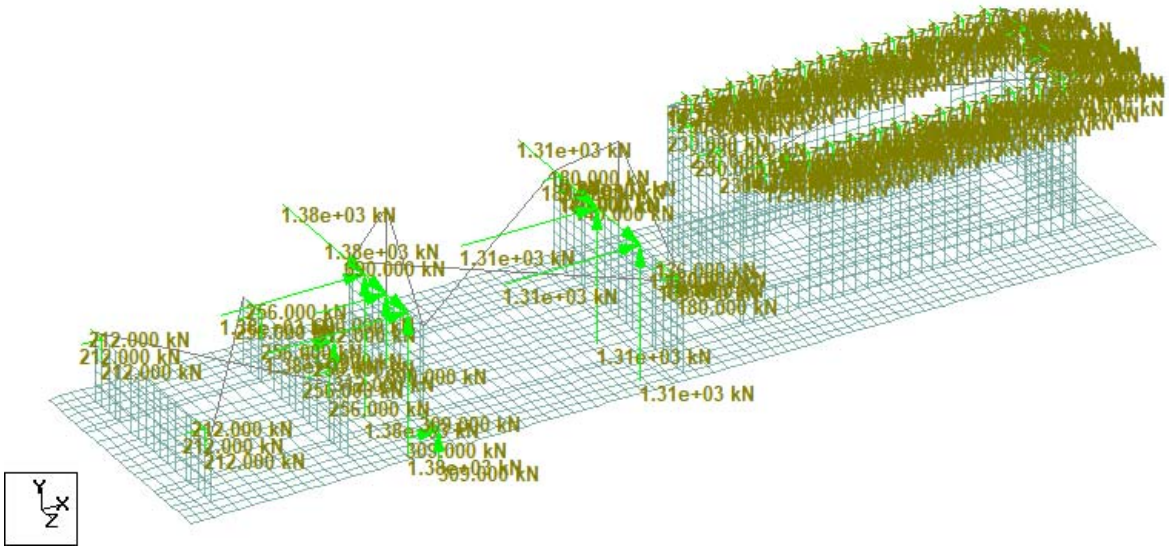
5.1 DESCRIZIONE

Lo scopo della presente analisi è quella di valutare le frequenze naturali della macchina e del Sistema Fondazione. Il Modello strutturale è stato sviluppato con il programma di calcolo STAAD ed I seguenti carichi sono stati considerati per il calcolo dei modi di vibrare del Sistema:

1) Peso proprio struttura

2) Pesi propri definiti dal Vendor.

In STAAD, le masse ed I modi sono definiti come di seguito:



5.2 FREQUENZE MODALI E MASSE PARTECIPANTI

Modo	Frequency Hz	Period seconds	Participation X %	Participation Y %	Participation Z %
1	11.717	0.085	0	0	61.59
2	14.464	0.069	88.924	0.063	0
3	16.378	0.061	0	0	28.139
4	22.236	0.045	8.279	1.256	0
5	22.476	0.044	0	0	3.964
6	26.677	0.037	0.519	55.763	0
7	27.714	0.036	0	0	0.206
8	28.535	0.035	1.306	36.055	0
9	34.899	0.029	0	0	4.869
10	38.138	0.026	0.358	1.965	0
11	41.347	0.024	0	0	0.639
12	44.45	0.022	0.255	0.257	0
13	46.266	0.022	0.033	1.283	0
14	50.726	0.02	0	0	0.299
15	56.298	0.018	0.034	2.925	0
16	59.3	0.017	0	0	0.147
17	74.357	0.013	0	0	0.006
18	77.472	0.013	0	0	0.062
19	83.217	0.012	0	0.002	0
20	85.213	0.012	0.135	0.083	0
21	88.327	0.011	0.041	0.043	0
22	89.859	0.011	0	0	0.035
23	89.991	0.011	0.032	0.002	0
24	101.042	0.01	0	0	0.004
25	104.402	0.01	0.001	0	0

Interpretazione

Dalla tabella riportata sopra, si evince che si ha circa il 100% della massa partecipata entro I primi 10 modi di vibrare. Per i modi di vibrare si rimanda all'Allegato B.

Inoltre, si evince che non ci sono anomalie nel comportamento strutturale della Fondazione.

Conclusioni

La frequenza naturale di vibrazione della Fondazione deve essere il 20% al di sotto del range operativo della macchina.

The natural frequency of vibration of foundation system shall be 20% beyond the machines operating range.

Frequenza della macchina = 3000 RPM = 50 Hz

La frequenza della Fondazione dovrà quindi stare al di fuori del range 40 Hz - 60 Hz.

Frequenza in Direzione X:

Modo 2 – Partecipante = 88.92%

Frequenza della fondazione = 14.46 Hz…… **OK**

Frequenza in Direzione Z:

Modo 1 – Partecipante = 61.59%

Frequenza della fondazione = 11.7 Hz…….. **OK**

Modo 3 – Partecipante = 28.14%

Frequenza della fondazione = 16.378 Hz…… **OK**

6 CAPACITA' DEI PALI

Il controllo statico dei pali è stato eseguito agli SLU.

Come da [5], per pali di diam. da 800mm, le capacità portanti agli SLU sono le seguenti:

1) Compressione = 2970 kN

2) Trazione = 1600 kN

3) Taglio = 203 kN

			Horizontal	Vertical	Horizontal	Moment		
	Node	L/C	Fx kN	Fy kN	Fz kN	Mx kN-m	My kN-m	Mz kN-m
Max Fx	412	2266 1DL-1	141.5	767.4	-48.7	224.0	2.2	-32.6
Min Fx	2058	2265 1DL-1	-147.6	966.8	-51.8	-550.2	-0.7	395.1
Max Fy	2058	2049 1.3DL	-32.9	1400.5	56.7	-211.4	-4.9	335.6
Min Fy	176	2270 1DL-1	-57.5	382.4	69.5	181.3	-2.8	155.0
Max Fz	1770	2134 1DL+1	-37.1	1067.8	194.7	5.8	-5.7	-176.9
Min Fz	1764	2269 1DL-1	-36.5	1064.9	-191.3	2.1	5.9	-176.0
Max Mx	2027	2134 1DL+1	-55.0	772.5	182.2	860.1	-5.6	152.1
Min Mx	2058	2269 1DL-1	-55.6	775.6	-178.2	-849.6	5.9	153.8
Max My	2027	2269 1DL-1	-35.4	1101.7	-180.8	-221.7	8.7	276.6
Min My	2058	2134 1DL+1	-36.1	1104.8	184.8	232.2	-8.3	278.3
Max Mz	2111	2045 1.3DL	-3.8	1034.5	-3.7	-6.8	-1.7	679.4
Min Mz	1912	2185 1.3DL	-20.5	1117.7	23.7	-662.2	-2.2	-439.6

Max. reazione vertical al palo = 1400.5 kN < 2970 kN **OK**

La risultante a taglio = $\sqrt{37.1^2 + 194.7^2}$ = 198.2 kN < 203 kN **OK**

Come da [5], per pali di diam. da 800mm, le capacità portanti agli SLE sono le seguenti:

1) Compressione = 1600 kN

2) Taglio = 142.5 kN

			Horizontal	Vertical	Horizontal	Moment		
	Node	L/C	Fx kN	Fy kN	Fz kN	Mx kN-m	My kN-m	Mz kN-m
Max Fx	412	1202 1DL-1	84.4	768.7	-28.5	271.1	1.4	17.5
Min Fx	2058	1201 1DL-1	-90.2	938.7	-29.9	-453.4	-0.5	289.7
Max Fy	2058	1041 1DL+1	-21.1	1100.9	55.6	-126.4	-4.4	252.9
Min Fy	176	1206 1DL-1	-36.4	401.0	43.3	167.7	-1.8	149.4
Max Fz	1770	1198 1DL+1	-23.8	989.8	118.4	-137.8	-4.0	-175.8
Min Fz	1764	1205 1DL-1	-23.2	986.9	-115.0	145.7	4.2	-174.9
Max Mx	1764	1198 1DL+1	-34.1	805.2	114.3	646.3	0.0	-94.7
Min Mx	1770	1205 1DL-1	-34.7	808.1	-110.9	-638.4	0.2	-95.5
Max My	2027	1205 1DL-1	-22.4	1023.6	-108.3	-21.2	5.6	217.8
Min My	2058	1198 1DL+1	-23.0	1026.7	112.3	31.7	-5.2	219.5
Max Mz	2111	1037 1DL+1	-2.8	835.7	-2.5	-3.5	-1.6	588.6
Min Mz	1912	1137 1DL-1	-12.9	907.5	19.8	-566.0	-1.9	-366.2

Max. reazione vertical al palo = 1100 kN < 1600 kN..... **OK**

La risultante a taglio = $\sqrt{23.8^2 + 118.4^2}$ = 120.8kN < 142.5 kN..... **OK**

7 ALLEGATO A – INPUT DA VENDOR

2.1. Foundation Plates Interface

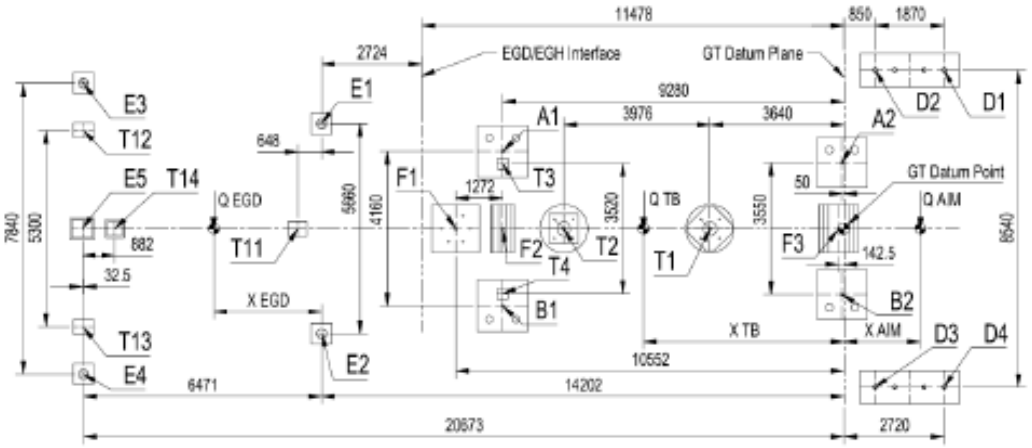


Figure 1: Foundation Plates Interface

3.1. Thermal Block and Exhaust Diffuser Loads

Location		Exhaust Diffuser					TBTurbine Side				TB Compressor Side		
Supports		E1	E2	E3	E4	E5	A1	B1	F1	F2	A2	B2	F3
Unit		kN	kN	kN	kN	kN	kN	kN	kN	kN	kN	kN	kN
Weight	x												
	y												
	z	-256	-256	-212	-212		-1379	-1379	-690		-1312	-1312	
Torque	x												
	y									-348			
	z						741	-741			-569	569	
Static Load	x												
	y									-348			
	z	-256	-256	-212	-212		-638	-2120	-690		-1880	-743	
Unbalance*	x												
	±y						170	149		1406	381	141	2935
	z						2425	2570		1518	1980	2597	1621
							-2811	-2525		-180	-5485	-4588	-2745
Earthquake	±x												4530
	±y					419				3173			1503
	±z						2384	2384			1542	1542	7621
Deflagration	x												1527
	y												
	z						193	193			-193	-193	2568
Weight + Unbalance	x												
	±y						170	149	0	1406			2935
	z	-256	-256	-212	-212	0	1046	1191	-690	1518	668	1285	1621
							-4190	-3904		-180	-6797	-5900	-2745
Static Load + Earthquake	x												4530
													-4530
	y					419				2825			1503
						-419				-3520			-1503
	z						1746	264			-338	799	7621
		-256	-256	-212	-212		-3022	-4505	-690		-3423	-2285	-7621

Location		EGD Service Supports				TB Service Supports			
Supports		T11	T12	T13	T14	T1	T2	T3	T4
Unit		kN	kN	kN	kN	kN	kN	kN	kN
Service Load	x				21				
	y								
	z	630	210	210		1470	1470	1470	1470

Figure 4: Thermal Block and Exhaust Diffuser Loads

3.2. Air Intake Manifold Loads

Location		Air Intake Manifold Top Intake			
Supports		D1	D2	D3	D4
Unit		kN	kN	kN	kN
Weight	x	-2	2	2	-2
	y	6	9	-9	-6
	z	-116	-64	-65	-115
Operating conditions (weight + pressure)	x	-23	-31	-31	-23
	y	-27	9	-9	27
	z	92	-114	-115	93
Operating conditions + Earthquake	x	25	35	35	25
		-70	-97	-97	-70
	y	16	89	71	70
		-71	-71	-90	-16
	z	321	112	111	323
		-138	-340	-341	-136
Operating conditions + Wind Load	x	-67	-104	-104	-67
	y	14	-52	52	-13
	z	397	-401	-401	398
Operating Conditions + Surge	x	40	68	68	37
		-44	-64	-64	-44
	y	71	9	-8	60
		-60	8	-10	-71
	z	299	35	35	308
		-530	-163	-165	-531

Figure 7: AIM Loads

.2.1. Max. Load AIM

Location		Air Intake Manifold Top Intake			
Supports		D1	D2	D3	D4
Unit		kN	kN	kN	kN
Max Load	x	40	68	68	37
		-70	-104	-104	-70
	y	71	89	71	70
		-71	-71	-90	-71
	z	397	112	111	398
		-530	-401	-401	-531

Figure 8: Max. loads of AIM

The natural frequency of vibration of foundation shall be 20% beyond the machines operating range and the maximum allowable amplitude for foundation vibration at frequency corresponding to machine operating speed shall be less than 50 micron (peak to peak), to guarantee good performance of machine.

NUMERATION OF THE FOUNDATION PLATES

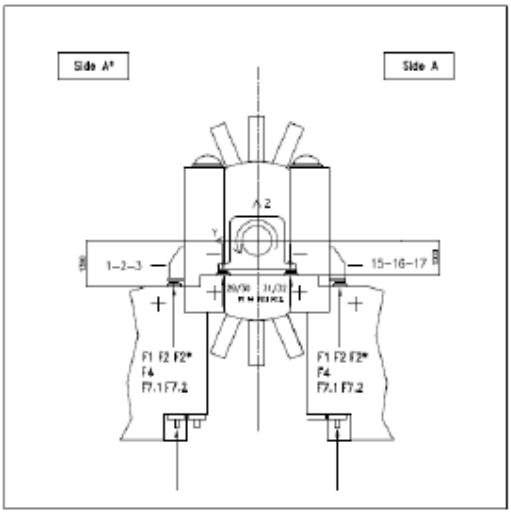


Fig. 1: View from turbine side.

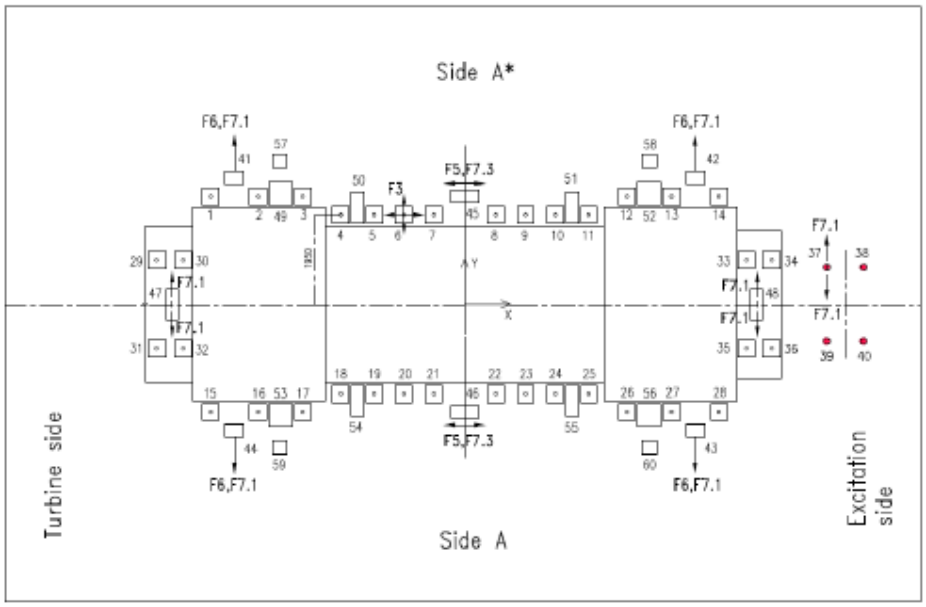
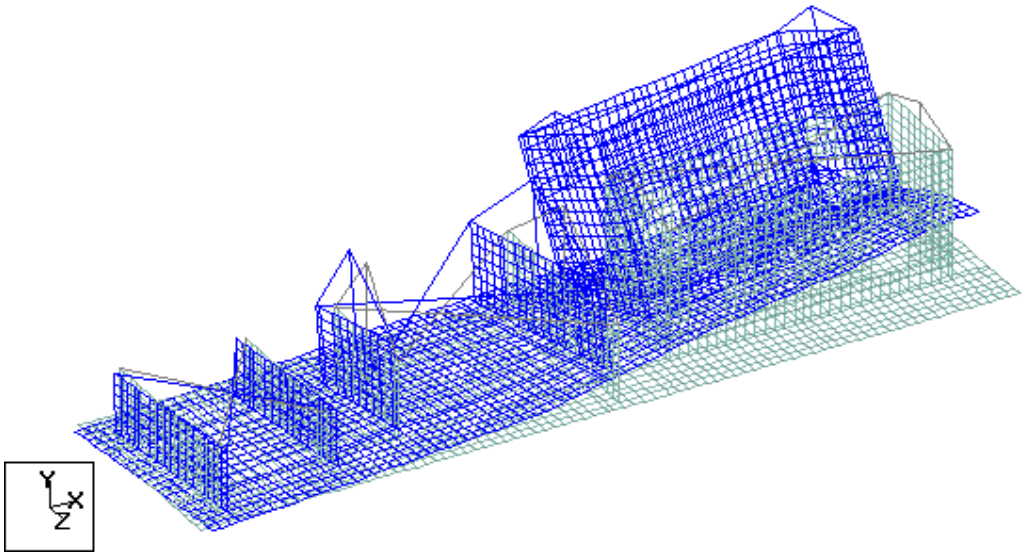


Fig. 2: Top view

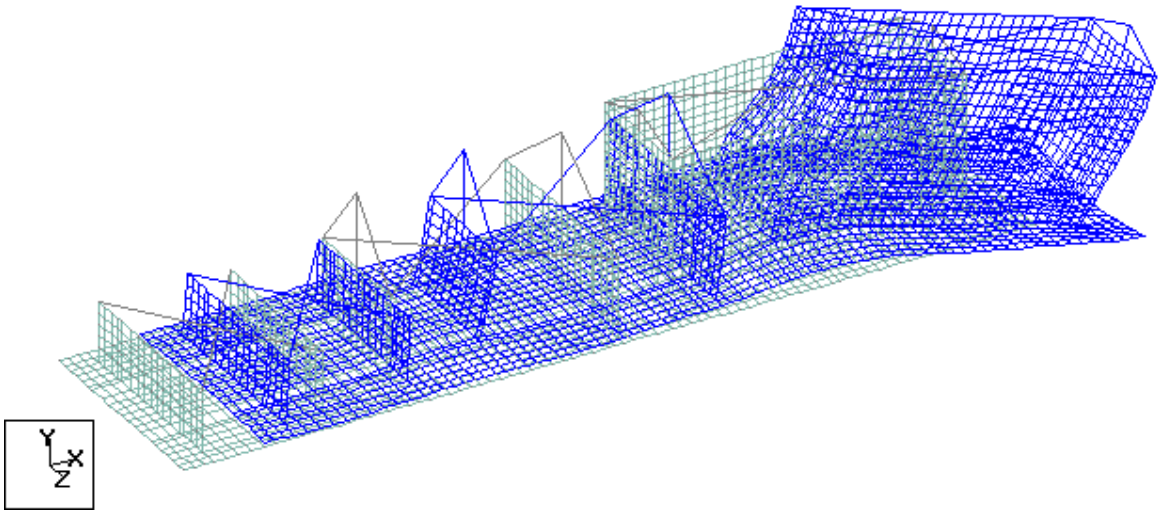
			Direction	1÷14	15÷28	29÷32	33÷36	37÷40	41÷44	45÷46	47÷48	49÷56	57÷60
A	F1	Vertical load due to weight	Z	-173	-173	-115	-115	-12					
			Y										
			X										
B	F2	Vertical load due to nominal torque	Z	-35	+35								
			Y										
			X										
B	F2*	Vertical load due to short-circuit	Z	±265	±265								
			Y										
			X										
B	F3	Horizontal load due to thermal effect	Z										
			Y	±303	±303								
			X	±303	±303								
B	F4	Radial rotating load due to magnetic unbalance (1)	Z	±2	±2	±5	±5						
			Y	±2	±2	±4	±4						
			X										
B	F5	Horizontal and axial load due to thermal effect on alignment constraints	Z										
			Y										
			X							±732**			
B	F6	Transversal load due to thermal effect on alignment constraints	Z										
			Y								±879***		
			X										
C	F7.1	Transversal earth quake (ah=0.4g)	Z	±46	±46	±48	±48						
			Y					±5	969		184		
			X										
C	F7.2	Vertical earth quake (av=0.4g)	Z	±69	±69	±46	±46	±5					
			Y										
			X										
C	F7.3	Axial earth quake * (aa=0.4g)	Z										
			Y										
			X					±5		±969			
A	F8	Vertical load due to weight during stator alignment	Z									-391	
			Y										
			X										
A	F9	Horizontal load due to weight during stator alignment	Z										
			Y										-469
			X										

8 ALLEGATO B – MODI DI VIBRARE

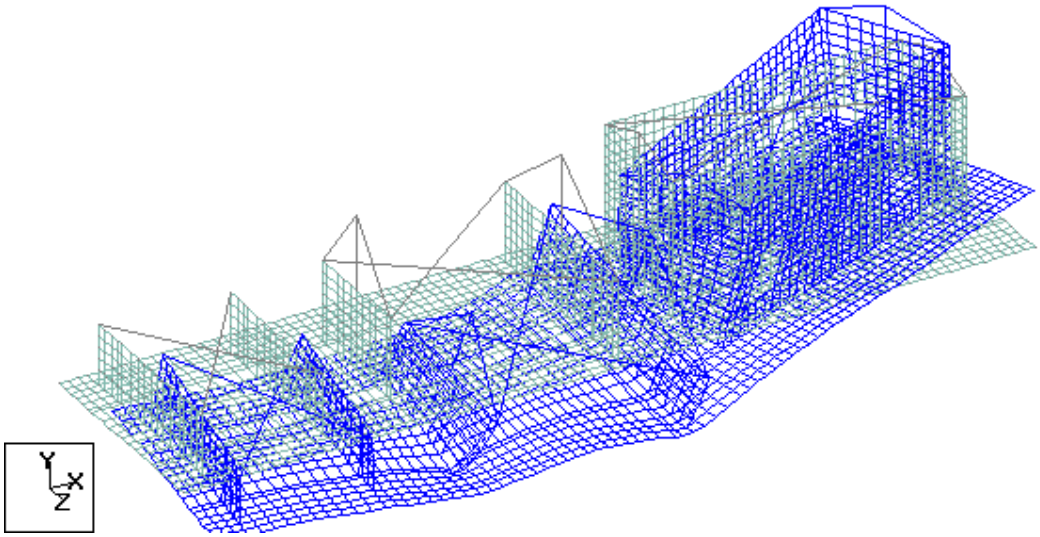
Vengono riportati di seguito i primi 10 modi di vibrare:



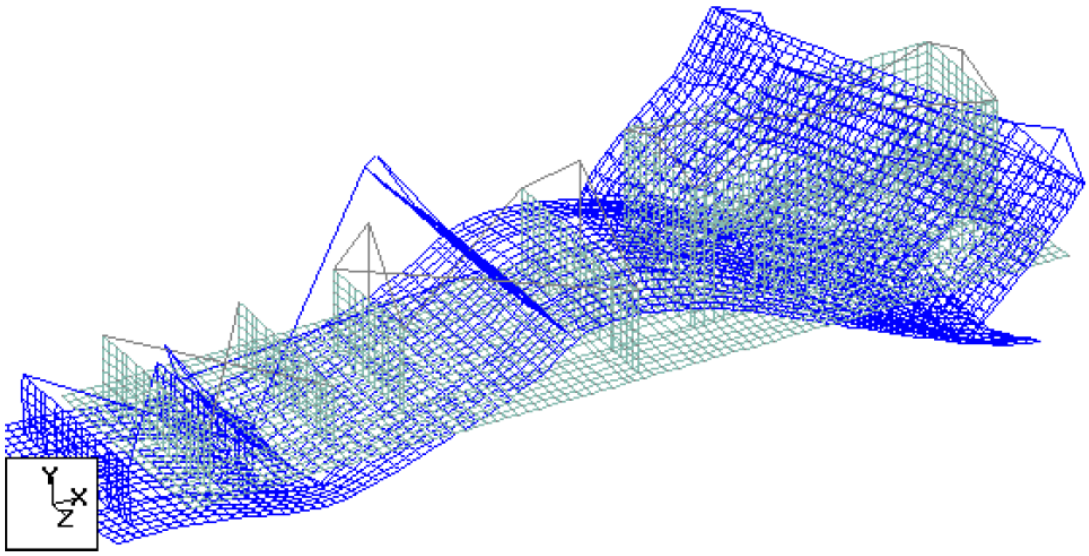
Modo 1



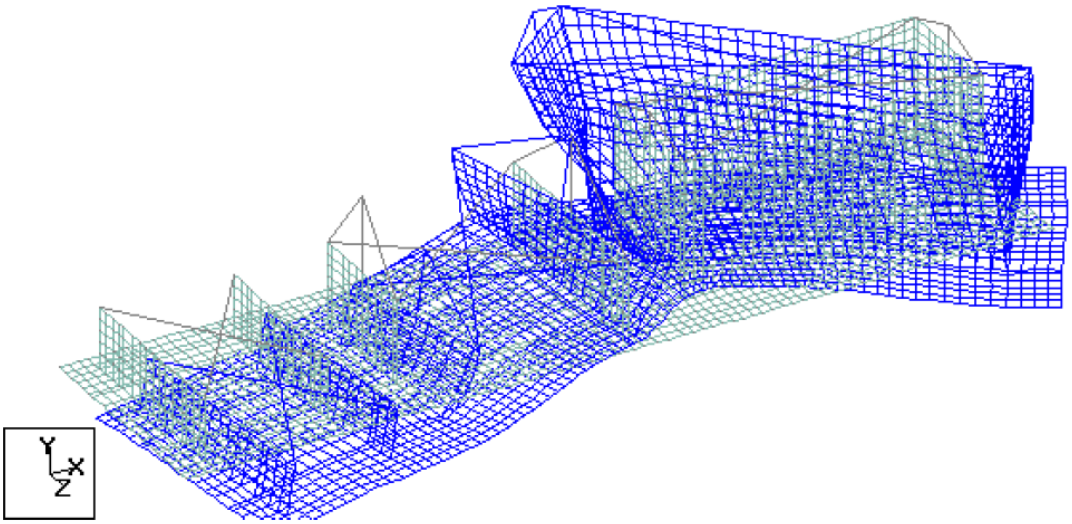
Modo 2



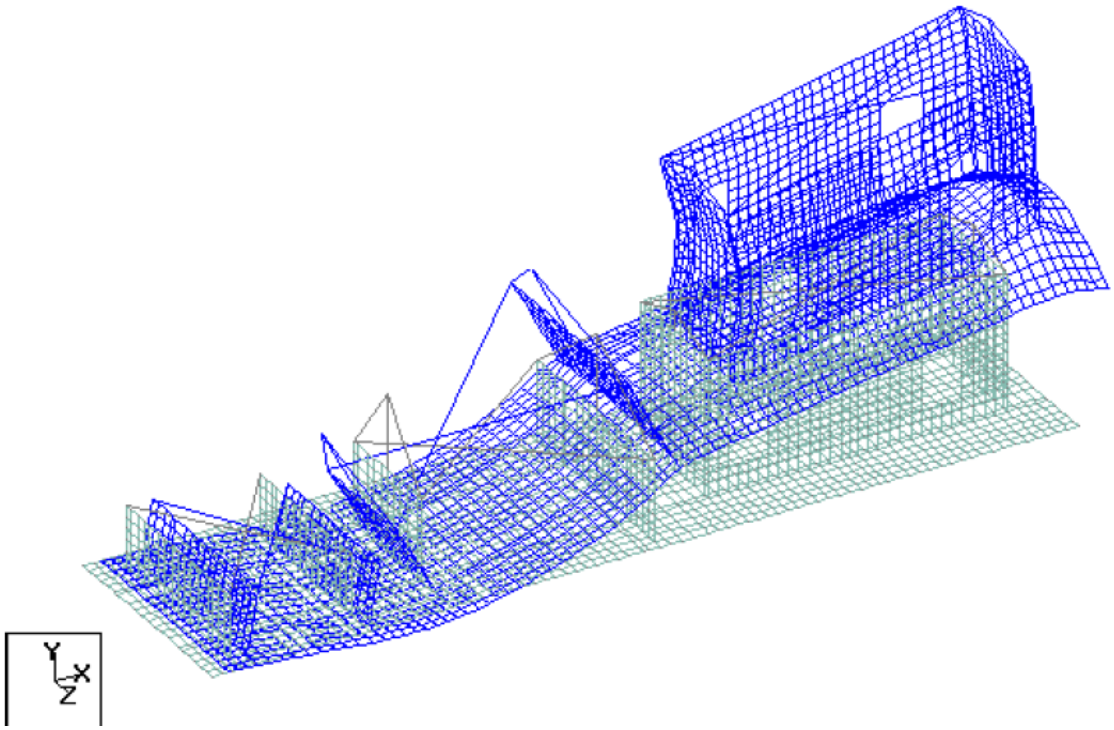
Modo 3



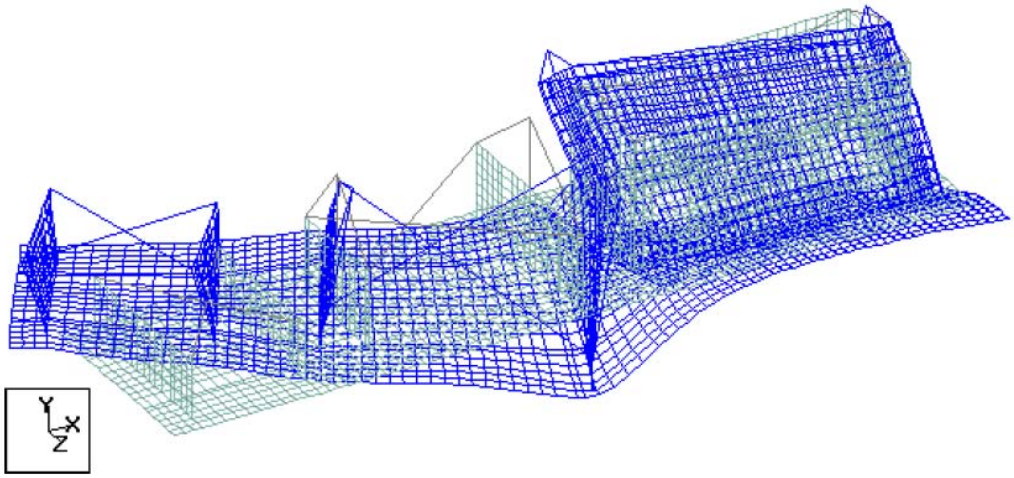
Modo 4



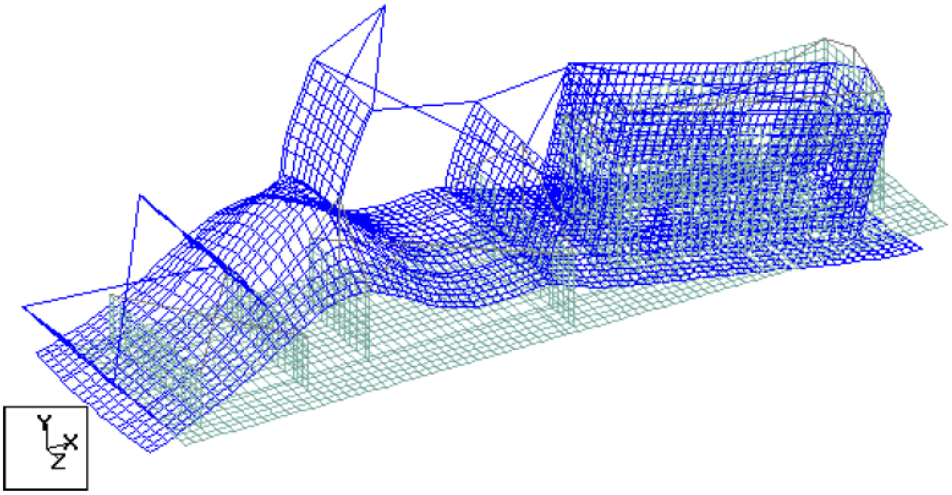
Modo 5



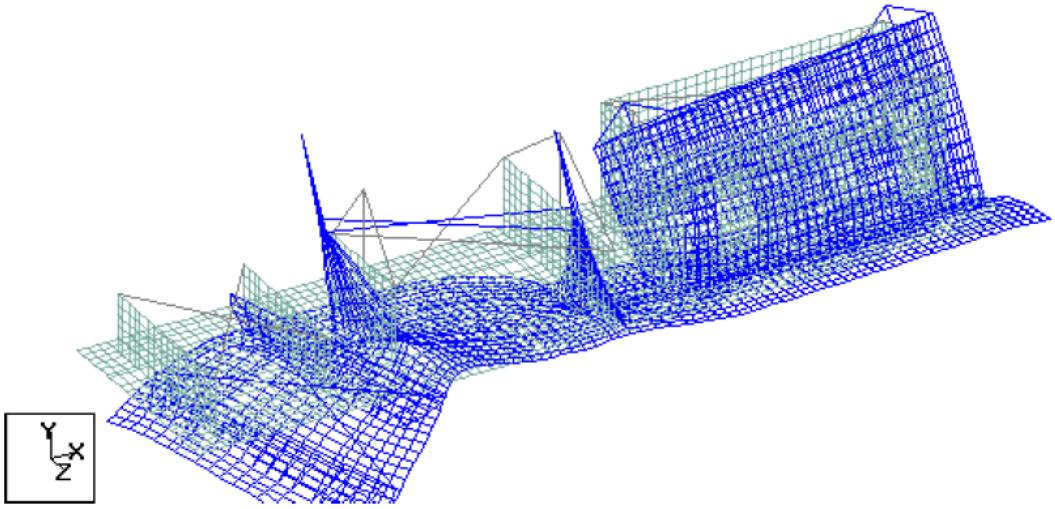
Modo 6



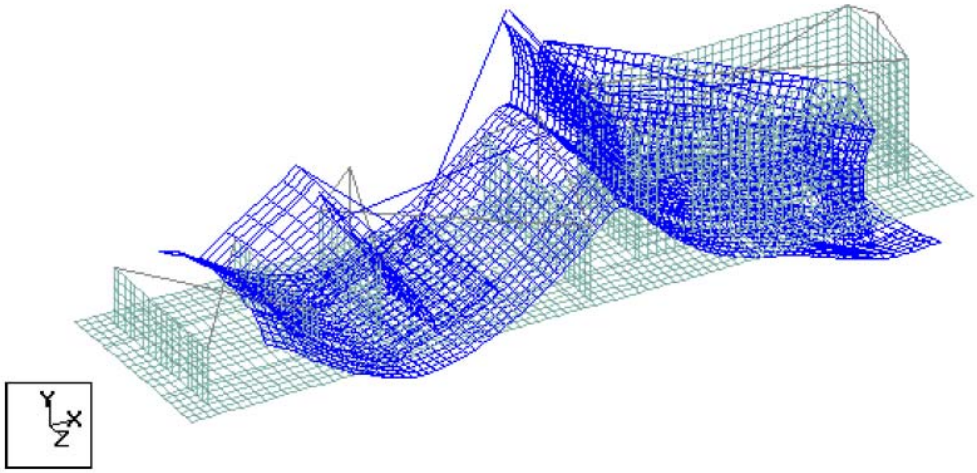
Modo 7



Modo 8



Modo 9



Modo 10

9 ALLEGATO C – COMBINAZIONI DI CARICO

LOAD COMB 1001 1DL+1OP+1LL+0.6TE+0.5SL+0.6WX
51 1.00 52 1.00 3 1.00 7 0.60 9 0.50 5 0.60
LOAD COMB 1002 1DL+1OP+1LL+0.6TE+0.5SL-0.6WX
51 1.00 52 1.00 3 1.00 7 0.60 9 0.50 5 -0.60
LOAD COMB 1003 1DL+1OP+1LL+0.6TE+0.5SL+0.6WY
51 1.00 52 1.00 3 1.00 7 0.60 9 0.50 6 0.60
LOAD COMB 1004 1DL+1OP+1LL+0.6TE+0.5SL-0.6WY
51 1.00 52 1.00 3 1.00 7 0.60 9 0.50 6 -0.60
LOAD COMB 1005 1DL+1OP+1LL+0.6TC+0.5SL+0.6WX
51 1.00 52 1.00 3 1.00 8 0.60 9 0.50 5 0.60
LOAD COMB 1006 1DL+1OP+1LL+0.6TC+0.5SL-0.6WX
51 1.00 52 1.00 3 1.00 8 0.60 9 0.50 5 -0.60
LOAD COMB 1007 1DL+1OP+1LL+0.6TC+0.5SL+0.6WY
51 1.00 52 1.00 3 1.00 8 0.60 9 0.50 6 0.60
LOAD COMB 1008 1DL+1OP+1LL+0.6TC+0.5SL-0.6WY
51 1.00 52 1.00 3 1.00 8 0.60 9 0.50 6 -0.60
LOAD COMB 1009 1DL+1OP+0.7LL+1TE+0.5SL+0.6WX
51 1.00 52 1.00 3 0.70 7 1.00 9 0.50 5 0.60
LOAD COMB 1010 1DL+1OP+0.7LL+1TE+0.5SL-0.6WX
51 1.00 52 1.00 3 0.70 7 1.00 9 0.50 5 -0.60
LOAD COMB 1011 1DL+1OP+0.7LL+1TE+0.5SL+0.6WY
51 1.00 52 1.00 3 0.70 7 1.00 9 0.50 6 0.60
LOAD COMB 1012 1DL+1OP+0.7LL+1TE+0.5SL-0.6WY
51 1.00 52 1.00 3 0.70 7 1.00 9 0.50 6 -0.60
LOAD COMB 1013 1DL+1OP+0.7LL+1TC+0.5SL+0.6WX
51 1.00 52 1.00 3 0.70 8 1.00 9 0.50 5 0.60
LOAD COMB 1014 1DL+1OP+0.7LL+1TC+0.5SL-0.6WX
51 1.00 52 1.00 3 0.70 8 1.00 9 0.50 5 -0.60
LOAD COMB 1015 1DL+1OP+0.7LL+1TC+0.5SL+0.6WY
51 1.00 52 1.00 3 0.70 8 1.00 9 0.50 6 0.60
LOAD COMB 1016 1DL+1OP+0.7LL+1TC+0.5SL-0.6WY
51 1.00 52 1.00 3 0.70 8 1.00 9 0.50 6 -0.60
LOAD COMB 1017 1DL+1OP+0.7LL+0.6TE+0.5SL+1WX
51 1.00 52 1.00 3 0.70 7 0.60 9 0.50 5 1.00
LOAD COMB 1018 1DL+1OP+0.7LL+0.6TE+0.5SL-1WX
51 1.00 52 1.00 3 0.70 7 0.60 9 0.50 5 -1.00
LOAD COMB 1019 1DL+1OP+0.7LL+0.6TE+0.5SL+1WY
51 1.00 52 1.00 3 0.70 7 0.60 9 0.50 6 1.00
LOAD COMB 1020 1DL+1OP+0.7LL+0.6TE+0.5SL-1WY
51 1.00 52 1.00 3 0.70 7 0.60 9 0.50 6 -1.00
LOAD COMB 1021 1DL+1OP+0.7LL+0.6TC+0.5SL+1WX
51 1.00 52 1.00 3 0.70 8 0.60 9 0.50 5 1.00
LOAD COMB 1022 1DL+1OP+0.7LL+0.6TC+0.5SL-1WX
51 1.00 52 1.00 3 0.70 8 0.60 9 0.50 5 -1.00
LOAD COMB 1023 1DL+1OP+0.7LL+0.6TC+0.5SL+1WY
51 1.00 52 1.00 3 0.70 8 0.60 9 0.50 6 1.00
LOAD COMB 1024 1DL+1OP+0.7LL+0.6TC+0.5SL-1WY
51 1.00 52 1.00 3 0.70 8 0.60 9 0.50 6 -1.00
LOAD COMB 1025 1DL+1OP+0.7LL+0.6TE+1SL+0.6WX
51 1.00 52 1.00 3 0.70 7 0.60 9 1.00 5 0.60
LOAD COMB 1026 1DL+1OP+0.7LL+0.6TE+1SL-0.6WX
51 1.00 52 1.00 3 0.70 7 0.60 9 1.00 5 -0.60
LOAD COMB 1027 1DL+1OP+0.7LL+0.6TE+1SL+0.6WY
51 1.00 52 1.00 3 0.70 7 0.60 9 1.00 6 0.60
LOAD COMB 1028 1DL+1OP+0.7LL+0.6TE+1SL-0.6WY
51 1.00 52 1.00 3 0.70 7 0.60 9 1.00 6 -0.60
LOAD COMB 1029 1DL+1OP+0.7LL+0.6TC+1SL+0.6WX
51 1.00 52 1.00 3 0.70 8 0.60 9 1.00 5 0.60
LOAD COMB 1030 1DL+1OP+0.7LL+0.6TC+1SL-0.6WX
51 1.00 52 1.00 3 0.70 8 0.60 9 1.00 5 -0.60
LOAD COMB 1031 1DL+1OP+0.7LL+0.6TC+1SL+0.6WY
51 1.00 52 1.00 3 0.70 8 0.60 9 1.00 6 0.60
LOAD COMB 1032 1DL+1OP+0.7LL+0.6TC+1SL-0.6WY

51 1.00 52 1.00 3 0.70 8 0.60 9 1.00 6 -0.60
LOAD COMB 1033 1DL+1OP+1LL+0.6TE+0.5SL+0.6WX+1SS
51 1.00 52 1.00 3 1.00 7 0.60 9 0.50 5 0.60 55 1.00
LOAD COMB 1034 1DL+1OP+1LL+0.6TE+0.5SL-0.6WX+1SS
51 1.00 52 1.00 3 1.00 7 0.60 9 0.50 5 -0.60 55 1.00
LOAD COMB 1035 1DL+1OP+1LL+0.6TE+0.5SL+0.6WY+1SS
51 1.00 52 1.00 3 1.00 7 0.60 9 0.50 6 0.60 55 1.00
LOAD COMB 1036 1DL+1OP+1LL+0.6TE+0.5SL-0.6WY+1SS
51 1.00 52 1.00 3 1.00 7 0.60 9 0.50 6 -0.60 55 1.00
LOAD COMB 1037 1DL+1OP+1LL+0.6TC+0.5SL+0.6WX+1SS
51 1.00 52 1.00 3 1.00 8 0.60 9 0.50 5 0.60 55 1.00
LOAD COMB 1038 1DL+1OP+1LL+0.6TC+0.5SL-0.6WX+1SS
51 1.00 52 1.00 3 1.00 8 0.60 9 0.50 5 -0.60 55 1.00
LOAD COMB 1039 1DL+1OP+1LL+0.6TC+0.5SL+0.6WY+1SS
51 1.00 52 1.00 3 1.00 8 0.60 9 0.50 6 0.60 55 1.00
LOAD COMB 1040 1DL+1OP+1LL+0.6TC+0.5SL-0.6WY+1SS
51 1.00 52 1.00 3 1.00 8 0.60 9 0.50 6 -0.60 55 1.00
LOAD COMB 1041 1DL+1OP+0.7LL+1TE+0.5SL+0.6WX+1SS
51 1.00 52 1.00 3 0.70 7 1.00 9 0.50 5 0.60 55 1.00
LOAD COMB 1042 1DL+1OP+0.7LL+1TE+0.5SL-0.6WX+1SS
51 1.00 52 1.00 3 0.70 7 1.00 9 0.50 5 -0.60 55 1.00
LOAD COMB 1043 1DL+1OP+0.7LL+1TE+0.5SL+0.6WY+1SS
51 1.00 52 1.00 3 0.70 7 1.00 9 0.50 6 0.60 55 1.00
LOAD COMB 1044 1DL+1OP+0.7LL+1TE+0.5SL-0.6WY+1SS
51 1.00 52 1.00 3 0.70 7 1.00 9 0.50 6 -0.60 55 1.00
LOAD COMB 1045 1DL+1OP+0.7LL+1TC+0.5SL+0.6WX+1SS
51 1.00 52 1.00 3 0.70 8 1.00 9 0.50 5 0.60 55 1.00
LOAD COMB 1046 1DL+1OP+0.7LL+1TC+0.5SL-0.6WX+1SS
51 1.00 52 1.00 3 0.70 8 1.00 9 0.50 5 -0.60 55 1.00
LOAD COMB 1047 1DL+1OP+0.7LL+1TC+0.5SL+0.6WY+1SS
51 1.00 52 1.00 3 0.70 8 1.00 9 0.50 6 0.60 55 1.00
LOAD COMB 1048 1DL+1OP+0.7LL+1TC+0.5SL-0.6WY+1SS
51 1.00 52 1.00 3 0.70 8 1.00 9 0.50 6 -0.60 55 1.00
LOAD COMB 1049 1DL+1OP+0.7LL+0.6TE+0.5SL+0.6WX+1SS
51 1.00 52 1.00 3 0.70 7 0.60 9 0.50 5 0.60 55 1.00
LOAD COMB 1050 1DL+1OP+0.7LL+0.6TE+0.5SL-0.6WX+1SS
51 1.00 52 1.00 3 0.70 7 0.60 9 0.50 5 -0.60 55 1.00
LOAD COMB 1051 1DL+1OP+0.7LL+0.6TE+0.5SL+0.6WY+1SS
51 1.00 52 1.00 3 0.70 7 0.60 9 0.50 6 0.60 55 1.00
LOAD COMB 1052 1DL+1OP+0.7LL+0.6TE+0.5SL-0.6WY+1SS
51 1.00 52 1.00 3 0.70 7 0.60 9 0.50 6 -0.60 55 1.00
LOAD COMB 1053 1DL+1OP+0.7LL+0.6TC+0.5SL+0.6WX+1SS
51 1.00 52 1.00 3 0.70 8 0.60 9 0.50 5 0.60 55 1.00
LOAD COMB 1054 1DL+1OP+0.7LL+0.6TC+0.5SL-0.6WX+1SS
51 1.00 52 1.00 3 0.70 8 0.60 9 0.50 5 -0.60 55 1.00
LOAD COMB 1055 1DL+1OP+0.7LL+0.6TC+0.5SL+0.6WY+1SS
51 1.00 52 1.00 3 0.70 8 0.60 9 0.50 6 0.60 55 1.00
LOAD COMB 1056 1DL+1OP+0.7LL+0.6TC+0.5SL-0.6WY+1SS
51 1.00 52 1.00 3 0.70 8 0.60 9 0.50 6 -0.60 55 1.00
LOAD COMB 1057 1DL+1OP+0.7LL+0.6TE+1SL+0.6WX+1SS
51 1.00 52 1.00 3 0.70 7 0.60 9 1.00 5 0.60 55 1.00
LOAD COMB 1058 1DL+1OP+0.7LL+0.6TE+1SL-0.6WX+1SS
51 1.00 52 1.00 3 0.70 7 0.60 9 1.00 5 -0.60 55 1.00
LOAD COMB 1059 1DL+1OP+0.7LL+0.6TE+1SL+0.6WY+1SS
51 1.00 52 1.00 3 0.70 7 0.60 9 1.00 6 0.60 55 1.00
LOAD COMB 1060 1DL+1OP+0.7LL+0.6TE+1SL-0.6WY+1SS
51 1.00 52 1.00 3 0.70 7 0.60 9 1.00 6 -0.60 55 1.00
LOAD COMB 1061 1DL+1OP+0.7LL+0.6TC+1SL+0.6WX+1SS
51 1.00 52 1.00 3 0.70 8 0.60 9 1.00 5 0.60 55 1.00
LOAD COMB 1062 1DL+1OP+0.7LL+0.6TC+1SL-0.6WX+1SS
51 1.00 52 1.00 3 0.70 8 0.60 9 1.00 5 -0.60 55 1.00
LOAD COMB 1063 1DL+1OP+0.7LL+0.6TC+1SL+0.6WY+1SS
51 1.00 52 1.00 3 0.70 8 0.60 9 1.00 6 0.60 55 1.00
LOAD COMB 1064 1DL+1OP+0.7LL+0.6TC+1SL-0.6WY+1SS
51 1.00 52 1.00 3 0.70 8 0.60 9 1.00 6 -0.60 55 1.00
LOAD COMB 1065 1DL-1OP+1LL+0.6TE+0.5SL+0.6WX
51 1.00 52 -1.00 3 1.00 7 0.60 9 0.50 5 0.60
LOAD COMB 1066 1DL-1OP+1LL+0.6TE+0.5SL-0.6WX
51 1.00 52 -1.00 3 1.00 7 0.60 9 0.50 5 -0.60
LOAD COMB 1067 1DL-1OP+1LL+0.6TE+0.5SL+0.6WY

51 1.00 52 -1.00 3 1.00 7 0.60 9 0.50 6 0.60
LOAD COMB 1068 1DL-1OP+1LL+0.6TE+0.5SL-0.6WY
51 1.00 52 -1.00 3 1.00 7 0.60 9 0.50 6 -0.60
LOAD COMB 1069 1DL-1OP+1LL+0.6TC+0.5SL+0.6WX
51 1.00 52 -1.00 3 1.00 8 0.60 9 0.50 5 0.60
LOAD COMB 1070 1DL-1OP+1LL+0.6TC+0.5SL-0.6WX
51 1.00 52 -1.00 3 1.00 8 0.60 9 0.50 5 -0.60
LOAD COMB 1071 1DL-1OP+1LL+0.6TC+0.5SL+0.6WY
51 1.00 52 -1.00 3 1.00 8 0.60 9 0.50 6 0.60
LOAD COMB 1072 1DL-1OP+1LL+0.6TC+0.5SL-0.6WY
51 1.00 52 -1.00 3 1.00 8 0.60 9 0.50 6 -0.60
LOAD COMB 1073 1DL-1OP+0.7LL+1TE+0.5SL+0.6WX
51 1.00 52 -1.00 3 0.70 7 1.00 9 0.50 5 0.60
LOAD COMB 1074 1DL-1OP+0.7LL+1TE+0.5SL-0.6WX
51 1.00 52 -1.00 3 0.70 7 1.00 9 0.50 5 -0.60
LOAD COMB 1075 1DL-1OP+0.7LL+1TE+0.5SL+0.6WY
51 1.00 52 -1.00 3 0.70 7 1.00 9 0.50 6 0.60
LOAD COMB 1076 1DL-1OP+0.7LL+1TE+0.5SL-0.6WY
51 1.00 52 -1.00 3 0.70 7 1.00 9 0.50 6 -0.60
LOAD COMB 1077 1DL-1OP+0.7LL+1TC+0.5SL+0.6WX
51 1.00 52 -1.00 3 0.70 8 1.00 9 0.50 5 0.60
LOAD COMB 1078 1DL-1OP+0.7LL+1TC+0.5SL-0.6WX
51 1.00 52 -1.00 3 0.70 8 1.00 9 0.50 5 -0.60
LOAD COMB 1079 1DL-1OP+0.7LL+1TC+0.5SL+0.6WY
51 1.00 52 -1.00 3 0.70 8 1.00 9 0.50 6 0.60
LOAD COMB 1080 1DL-1OP+0.7LL+1TC+0.5SL-0.6WY
51 1.00 52 -1.00 3 0.70 8 1.00 9 0.50 6 -0.60
LOAD COMB 1081 1DL-1OP+0.7LL+0.6TE+0.5SL+1WX
51 1.00 52 -1.00 3 0.70 7 0.60 9 0.50 5 1.00
LOAD COMB 1082 1DL-1OP+0.7LL+0.6TE+0.5SL-1WX
51 1.00 52 -1.00 3 0.70 7 0.60 9 0.50 5 -1.00
LOAD COMB 1083 1DL-1OP+0.7LL+0.6TE+0.5SL+1WY
51 1.00 52 -1.00 3 0.70 7 0.60 9 0.50 6 1.00
LOAD COMB 1084 1DL-1OP+0.7LL+0.6TE+0.5SL-1WY
51 1.00 52 -1.00 3 0.70 7 0.60 9 0.50 6 -1.00
LOAD COMB 1085 1DL-1OP+0.7LL+0.6TC+0.5SL+1WX
51 1.00 52 -1.00 3 0.70 8 0.60 9 0.50 5 1.00
LOAD COMB 1086 1DL-1OP+0.7LL+0.6TC+0.5SL-1WX
51 1.00 52 -1.00 3 0.70 8 0.60 9 0.50 5 -1.00
LOAD COMB 1087 1DL-1OP+0.7LL+0.6TC+0.5SL+1WY
51 1.00 52 -1.00 3 0.70 8 0.60 9 0.50 6 1.00
LOAD COMB 1088 1DL-1OP+0.7LL+0.6TC+0.5SL-1WY
51 1.00 52 -1.00 3 0.70 8 0.60 9 0.50 6 -1.00
LOAD COMB 1089 1DL-1OP+0.7LL+0.6TE+1SL+0.6WX
51 1.00 52 -1.00 3 0.70 7 0.60 9 1.00 5 0.60
LOAD COMB 1090 1DL-1OP+0.7LL+0.6TE+1SL-0.6WX
51 1.00 52 -1.00 3 0.70 7 0.60 9 1.00 5 -0.60
LOAD COMB 1091 1DL-1OP+0.7LL+0.6TE+1SL+0.6WY
51 1.00 52 -1.00 3 0.70 7 0.60 9 1.00 6 0.60
LOAD COMB 1092 1DL-1OP+0.7LL+0.6TE+1SL-0.6WY
51 1.00 52 -1.00 3 0.70 7 0.60 9 1.00 6 -0.60
LOAD COMB 1093 1DL-1OP+0.7LL+0.6TC+1SL+0.6WX
51 1.00 52 -1.00 3 0.70 8 0.60 9 1.00 5 0.60
LOAD COMB 1094 1DL-1OP+0.7LL+0.6TC+1SL-0.6WX
51 1.00 52 -1.00 3 0.70 8 0.60 9 1.00 5 -0.60
LOAD COMB 1095 1DL-1OP+0.7LL+0.6TC+1SL+0.6WY
51 1.00 52 -1.00 3 0.70 8 0.60 9 1.00 6 0.60
LOAD COMB 1096 1DL-1OP+0.7LL+0.6TC+1SL-0.6WY+1SS
51 1.00 52 -1.00 3 0.70 8 0.60 9 1.00 6 -0.60 55 1.00
LOAD COMB 1097 1DL-1OP+1LL+0.6TE+0.5SL+0.6WX+1SS
51 1.00 52 -1.00 3 1.00 7 0.60 9 0.50 5 0.60 55 1.00
LOAD COMB 1098 1DL-1OP+1LL+0.6TE+0.5SL-0.6WX+1SS
51 1.00 52 -1.00 3 1.00 7 0.60 9 0.50 5 -0.60 55 1.00
LOAD COMB 1099 1DL-1OP+1LL+0.6TE+0.5SL+0.6WY+1SS
51 1.00 52 -1.00 3 1.00 7 0.60 9 0.50 6 0.60 55 1.00
LOAD COMB 1100 1DL-1OP+1LL+0.6TE+0.5SL-0.6WY+1SS
51 1.00 52 -1.00 3 1.00 7 0.60 9 0.50 6 -0.60 55 1.00
LOAD COMB 1101 1DL-1OP+1LL+0.6TC+0.5SL+0.6WX+1SS
51 1.00 52 -1.00 3 1.00 8 0.60 9 0.50 5 0.60 55 1.00
LOAD COMB 1102 1DL-1OP+1LL+0.6TC+0.5SL-0.6WX+1SS

51 1.00 52 -1.00 3 1.00 8 0.60 9 0.50 5 -0.60 55 1.00
LOAD COMB 1103 1DL-1OP+1LL+0.6TC+0.5SL+0.6WY+1SS
51 1.00 52 -1.00 3 1.00 8 0.60 9 0.50 6 0.60 55 1.00
LOAD COMB 1104 1DL-1OP+1LL+0.6TC+0.5SL-0.6WY+1SS
51 1.00 52 -1.00 3 1.00 8 0.60 9 0.50 6 -0.60 55 1.00
LOAD COMB 1105 1DL-1OP+0.7LL+1TE+0.5SL+0.6WX+1SS
51 1.00 52 -1.00 3 0.70 7 1.00 9 0.50 5 0.60 55 1.00
LOAD COMB 1106 1DL-1OP+0.7LL+1TE+0.5SL-0.6WX+1SS
51 1.00 52 -1.00 3 0.70 7 1.00 9 0.50 5 -0.60 55 1.00
LOAD COMB 1107 1DL-1OP+0.7LL+1TE+0.5SL+0.6WY+1SS
51 1.00 52 -1.00 3 0.70 7 1.00 9 0.50 6 0.60 55 1.00
LOAD COMB 1108 1DL-1OP+0.7LL+1TE+0.5SL-0.6WY+1SS
51 1.00 52 -1.00 3 0.70 7 1.00 9 0.50 6 -0.60 55 1.00
LOAD COMB 1109 1DL-1OP+0.7LL+1TC+0.5SL+0.6WX+1SS
51 1.00 52 -1.00 3 0.70 8 1.00 9 0.50 5 0.60 55 1.00
LOAD COMB 1110 1DL-1OP+0.7LL+1TC+0.5SL-0.6WX+1SS
51 1.00 52 -1.00 3 0.70 8 1.00 9 0.50 5 -0.60 55 1.00
LOAD COMB 1111 1DL-1OP+0.7LL+1TC+0.5SL+0.6WY+1SS
51 1.00 52 -1.00 3 0.70 8 1.00 9 0.50 6 0.60 55 1.00
LOAD COMB 1112 1DL-1OP+0.7LL+1TC+0.5SL-0.6WY+1SS
51 1.00 52 -1.00 3 0.70 8 1.00 9 0.50 6 -0.60 55 1.00
LOAD COMB 1113 1DL-1OP+0.7LL+0.6TE+0.5SL+0.6WX+1SS
51 1.00 52 -1.00 3 0.70 7 0.60 9 0.50 5 0.60 55 1.00
LOAD COMB 1114 1DL-1OP+0.7LL+0.6TE+0.5SL-0.6WX+1SS
51 1.00 52 -1.00 3 0.70 7 0.60 9 0.50 5 -0.60 55 1.00
LOAD COMB 1115 1DL-1OP+0.7LL+0.6TE+0.5SL+0.6WY+1SS
51 1.00 52 -1.00 3 0.70 7 0.60 9 0.50 6 0.60 55 1.00
LOAD COMB 1116 1DL-1OP+0.7LL+0.6TE+0.5SL-0.6WY+1SS
51 1.00 52 -1.00 3 0.70 7 0.60 9 0.50 6 -0.60 55 1.00
LOAD COMB 1117 1DL-1OP+0.7LL+0.6TC+0.5SL+0.6WX+1SS
51 1.00 52 -1.00 3 0.70 8 0.60 9 0.50 5 0.60 55 1.00
LOAD COMB 1118 1DL-1OP+0.7LL+0.6TC+0.5SL-0.6WX+1SS
51 1.00 52 -1.00 3 0.70 8 0.60 9 0.50 5 -0.60 55 1.00
LOAD COMB 1119 1DL-1OP+0.7LL+0.6TC+0.5SL+0.6WY+1SS
51 1.00 52 -1.00 3 0.70 8 0.60 9 0.50 6 0.60 55 1.00
LOAD COMB 1120 1DL-1OP+0.7LL+0.6TC+0.5SL-0.6WY+1SS
51 1.00 52 -1.00 3 0.70 8 0.60 9 0.50 6 -0.60 55 1.00
LOAD COMB 1121 1DL-1OP+0.7LL+0.6TE+1SL+0.6WX+1SS
51 1.00 52 -1.00 3 0.70 7 0.60 9 1.00 5 0.60 55 1.00
LOAD COMB 1122 1DL-1OP+0.7LL+0.6TE+1SL-0.6WX+1SS
51 1.00 52 -1.00 3 0.70 7 0.60 9 1.00 5 -0.60 55 1.00
LOAD COMB 1123 1DL-1OP+0.7LL+0.6TE+1SL+0.6WY+1SS
51 1.00 52 -1.00 3 0.70 7 0.60 9 1.00 6 0.60 55 1.00
LOAD COMB 1124 1DL-1OP+0.7LL+0.6TE+1SL-0.6WY+1SS
51 1.00 52 -1.00 3 0.70 7 0.60 9 1.00 6 -0.60 55 1.00
LOAD COMB 1125 1DL-1OP+0.7LL+0.6TC+1SL+0.6WX+1SS
51 1.00 52 -1.00 3 0.70 8 0.60 9 1.00 5 0.60 55 1.00
LOAD COMB 1126 1DL-1OP+0.7LL+0.6TC+1SL-0.6WX+1SS
51 1.00 52 -1.00 3 0.70 8 0.60 9 1.00 5 -0.60 55 1.00
LOAD COMB 1127 1DL-1OP+0.7LL+0.6TC+1SL+0.6WY+1SS
51 1.00 52 -1.00 3 0.70 8 0.60 9 1.00 6 0.60 55 1.00
LOAD COMB 1128 1DL-1OP+0.7LL+0.6TC+1SL-0.6WY+1SS
51 1.00 52 -1.00 3 0.70 8 0.60 9 1.00 6 -0.60 55 1.00
LOAD COMB 1129 1DL+1OP+0.6LL+1EXE+0.3EZE
51 1.00 52 1.00 3 0.60 18 1.00 19 0.30
LOAD COMB 1130 1DL+1OP+0.6LL-1EXE+0.3EZE
51 1.00 52 1.00 3 0.60 18 -1.00 19 0.30
LOAD COMB 1131 1DL+1OP+0.6LL+1EXE-0.3EZE
51 1.00 52 1.00 3 0.60 18 1.00 19 -0.30
LOAD COMB 1132 1DL+1OP+0.6LL-1EXE-0.3EZE
51 1.00 52 1.00 3 0.60 18 -1.00 19 -0.30
LOAD COMB 1133 1DL+1OP+0.6LL+0.3EXE+1EZE
51 1.00 52 1.00 3 0.60 18 0.30 19 1.00
LOAD COMB 1134 1DL+1OP+0.6LL+0.3EXE-1EZE
51 1.00 52 1.00 3 0.60 18 0.30 19 -1.00
LOAD COMB 1135 1DL+1OP+0.6LL-0.3EXE+1EZE
51 1.00 52 1.00 3 0.60 18 -0.30 19 1.00
LOAD COMB 1136 1DL+1OP+0.6LL-0.3EXE-1EZE
51 1.00 52 1.00 3 0.60 18 -0.30 19 -1.00
LOAD COMB 1137 1DL-1OP+0.6LL+1EXE+0.3EZE

51 1.00 52 -1.00 3 0.60 18 1.00 19 0.30
LOAD COMB 1138 1DL-1OP+0.6LL-1EXE+0.3EZE
51 1.00 52 -1.00 3 0.60 18 -1.00 19 0.30
LOAD COMB 1139 1DL-1OP+0.6LL+1EXE-0.3EZE
51 1.00 52 -1.00 3 0.60 18 1.00 19 -0.30
LOAD COMB 1140 1DL-1OP+0.6LL-1EXE-0.3EZE
51 1.00 52 -1.00 3 0.60 18 -1.00 19 -0.30
LOAD COMB 1141 1DL-1OP+0.6LL+0.3EXE+1EZE
51 1.00 52 -1.00 3 0.60 18 0.30 19 1.00
LOAD COMB 1142 1DL-1OP+0.6LL+0.3EXE-1EZE
51 1.00 52 -1.00 3 0.60 18 0.30 19 -1.00
LOAD COMB 1143 1DL-1OP+0.6LL-0.3EXE+1EZE
51 1.00 52 -1.00 3 0.60 18 -0.30 19 1.00
LOAD COMB 1144 1DL-1OP+0.6LL-0.3EXE-1EZE
51 1.00 52 -1.00 3 0.60 18 -0.30 19 -1.00
LOAD COMB 2001 1.3DL+3.9OP+1.5LL+0.9TE+0.9SL+0.9WX
51 1.30 52 3.90 3 1.50 7 0.90 9 0.90 5 0.90
LOAD COMB 2002 1.3DL+3.9OP+1.5LL+0.9TE+0.9SL-0.9WX
51 1.30 52 3.90 3 1.50 7 0.90 9 0.90 5 -0.90
LOAD COMB 2003 1.3DL+3.9OP+1.5LL+0.9TE+0.9SL+0.9WY
51 1.30 52 3.90 3 1.50 7 0.90 9 0.90 6 0.90
LOAD COMB 2004 1.3DL+3.9OP+1.5LL+0.9TE+0.9SL-0.9WY
51 1.30 52 3.90 3 1.50 7 0.90 9 0.90 6 -0.90
LOAD COMB 2005 1.3DL+3.9OP+1.5LL+0.9TC+0.9SL+0.9WX
51 1.30 52 3.90 3 1.50 8 0.90 9 0.90 5 0.90
LOAD COMB 2006 1.3DL+3.9OP+1.5LL+0.9TC+0.9SL-0.9WX
51 1.30 52 3.90 3 1.50 8 0.90 9 0.90 5 -0.90
LOAD COMB 2007 1.3DL+3.9OP+1.5LL+0.9TC+0.9SL+0.9WY
51 1.30 52 3.90 3 1.50 8 0.90 9 0.90 6 0.90
LOAD COMB 2008 1.3DL+3.9OP+1.5LL+0.9TC+0.9SL-0.9WY
51 1.30 52 3.90 3 1.50 8 0.90 9 0.90 6 -0.90
LOAD COMB 2009 1.3DL+3.9OP+1.5LL+0.9TE+1.5SL+0.9WX
51 1.30 52 3.90 3 1.50 7 0.90 9 1.50 5 0.90
LOAD COMB 2010 1.3DL+3.9OP+1.5LL+0.9TE+1.5SL-0.9WX
51 1.30 52 3.90 3 1.50 7 0.90 9 1.50 5 -0.90
LOAD COMB 2011 1.3DL+3.9OP+1.5LL+0.9TE+1.5SL+0.9WY
51 1.30 52 3.90 3 1.50 7 0.90 9 1.50 6 0.90
LOAD COMB 2012 1.3DL+3.9OP+1.5LL+0.9TE+1.5SL-0.9WY
51 1.30 52 3.90 3 1.50 7 0.90 9 1.50 6 -0.90
LOAD COMB 2013 1.3DL+3.9OP+1.5LL+0.9TC+1.5SL+0.9WX
51 1.30 52 3.90 3 1.50 8 0.90 9 1.50 5 0.90
LOAD COMB 2014 1.3DL+3.9OP+1.5LL+0.9TC+1.5SL-0.9WX
51 1.30 52 3.90 3 1.50 8 0.90 9 1.50 5 -0.90
LOAD COMB 2015 1.3DL+3.9OP+1.5LL+0.9TC+1.5SL+0.9WY
51 1.30 52 3.90 3 1.50 8 0.90 9 1.50 6 0.90
LOAD COMB 2016 1.3DL+3.9OP+1.5LL+0.9TC+1.5SL-0.9WY
51 1.30 52 3.90 3 1.50 8 0.90 9 1.50 6 -0.90
LOAD COMB 2017 1.3DL+3.9OP+1.5LL+1.5TE+0.9SL+0.9WX
51 1.30 52 3.90 3 1.50 7 1.50 9 0.90 5 0.90
LOAD COMB 2018 1.3DL+3.9OP+1.5LL+1.5TE+0.9SL-0.9WX
51 1.30 52 3.90 3 1.50 7 1.50 9 0.90 5 -0.90
LOAD COMB 2019 1.3DL+3.9OP+1.5LL+1.5TE+0.9SL+0.9WY
51 1.30 52 3.90 3 1.50 7 1.50 9 0.90 6 0.90
LOAD COMB 2020 1.3DL+3.9OP+1.5LL+1.5TE+0.9SL-0.9WY
51 1.30 52 3.90 3 1.50 7 1.50 9 0.90 6 -0.90
LOAD COMB 2021 1.3DL+3.9OP+1.5LL+1.5TC+0.9SL+0.9WX
51 1.30 52 3.90 3 1.50 8 1.50 9 0.90 5 0.90
LOAD COMB 2022 1.3DL+3.9OP+1.5LL+1.5TC+0.9SL-0.9WX
51 1.30 52 3.90 3 1.50 8 1.50 9 0.90 5 -0.90
LOAD COMB 2023 1.3DL+3.9OP+1.5LL+1.5TC+0.9SL+0.9WY
51 1.30 52 3.90 3 1.50 8 1.50 9 0.90 6 0.90
LOAD COMB 2024 1.3DL+3.9OP+1.5LL+1.5TC+0.9SL-0.9WY
51 1.30 52 3.90 3 1.50 8 1.50 9 0.90 6 -0.90
LOAD COMB 2025 1.3DL+3.9OP+1.5LL+0.9TE+0.9SL+1.5WX
51 1.30 52 3.90 3 1.50 7 0.90 9 0.90 5 1.50
LOAD COMB 2026 1.3DL+3.9OP+1.5LL+0.9TE+0.9SL-1.5WX
51 1.30 52 3.90 3 1.50 7 0.90 9 0.90 5 -1.50
LOAD COMB 2027 1.3DL+3.9OP+1.5LL+0.9TE+0.9SL+1.5WY
51 1.30 52 3.90 3 1.50 7 0.90 9 0.90 6 1.50
LOAD COMB 2028 1.3DL+3.9OP+1.5LL+0.9TE+0.9SL-1.5WY

51 1.30 52 3.90 3 1.50 7 0.90 9 0.90 6 -1.50
LOAD COMB 2029 1.3DL+3.9OP+1.5LL+0.9TC+0.9SL+1.5WX
51 1.30 52 3.90 3 1.50 8 0.90 9 0.90 5 1.50
LOAD COMB 2030 1.3DL+3.9OP+1.5LL+0.9TC+0.9SL-1.5WX
51 1.30 52 3.90 3 1.50 8 0.90 9 0.90 5 -1.50
LOAD COMB 2031 1.3DL+3.9OP+1.5LL+0.9TC+0.9SL+1.5WY
51 1.30 52 3.90 3 1.50 8 0.90 9 0.90 6 1.50
LOAD COMB 2032 1.3DL+3.9OP+1.5LL+0.9TC+0.9SL-1.5WY
51 1.30 52 3.90 3 1.50 8 0.90 9 0.90 6 -1.50
LOAD COMB 2033 1.3DL+1.3OP+1.5LL+0.9TE+0.9SL+0.9WX+1SS
51 1.30 52 1.30 3 1.50 7 0.90 9 0.90 5 0.90 55 1.00
LOAD COMB 2034 1.3DL+1.3OP+1.5LL+0.9TE+0.9SL-0.9WX+1SS
51 1.30 52 1.30 3 1.50 7 0.90 9 0.90 5 -0.90 55 1.00
LOAD COMB 2035 1.3DL+1.3OP+1.5LL+0.9TE+0.9SL+0.9WY+1SS
51 1.30 52 1.30 3 1.50 7 0.90 9 0.90 6 0.90 55 1.00
LOAD COMB 2036 1.3DL+1.3OP+1.5LL+0.9TE+0.9SL-0.9WY+1SS
51 1.30 52 1.30 3 1.50 7 0.90 9 0.90 6 -0.90 55 1.00
LOAD COMB 2037 1.3DL+1.3OP+1.5LL+0.9TC+0.9SL+0.9WX+1SS
51 1.30 52 1.30 3 1.50 8 0.90 9 0.90 5 0.90 55 1.00
LOAD COMB 2038 1.3DL+1.3OP+1.5LL+0.9TC+0.9SL-0.9WX+1SS
51 1.30 52 1.30 3 1.50 8 0.90 9 0.90 5 -0.90 55 1.00
LOAD COMB 2039 1.3DL+1.3OP+1.5LL+0.9TC+0.9SL+0.9WY+1SS
51 1.30 52 1.30 3 1.50 8 0.90 9 0.90 6 0.90 55 1.00
LOAD COMB 2040 1.3DL+1.3OP+1.5LL+0.9TC+0.9SL-0.9WY+1SS
51 1.30 52 1.30 3 1.50 8 0.90 9 0.90 6 -0.90 55 1.00
LOAD COMB 2041 1.3DL+1.3OP+1.5LL+0.9TE+1.5SL+0.9WX+1SS
51 1.30 52 1.30 3 1.50 7 0.90 9 1.50 5 0.90 55 1.00
LOAD COMB 2042 1.3DL+1.3OP+1.5LL+0.9TE+1.5SL-0.9WX+1SS
51 1.30 52 1.30 3 1.50 7 0.90 9 1.50 5 -0.90 55 1.00
LOAD COMB 2043 1.3DL+1.3OP+1.5LL+0.9TE+1.5SL+0.9WY+1SS
51 1.30 52 1.30 3 1.50 7 0.90 9 1.50 6 0.90 55 1.00
LOAD COMB 2044 1.3DL+1.3OP+1.5LL+0.9TE+1.5SL-0.9WY+1SS
51 1.30 52 1.30 3 1.50 7 0.90 9 1.50 6 -0.90 55 1.00
LOAD COMB 2045 1.3DL+1.3OP+1.5LL+0.9TC+1.5SL+0.9WX+1SS
51 1.30 52 1.30 3 1.50 8 0.90 9 1.50 5 0.90 55 1.00
LOAD COMB 2046 1.3DL+1.3OP+1.5LL+0.9TC+1.5SL-0.9WX+1SS
51 1.30 52 1.30 3 1.50 8 0.90 9 1.50 5 -0.90 55 1.00
LOAD COMB 2047 1.3DL+1.3OP+1.5LL+0.9TC+1.5SL+0.9WY+1SS
51 1.30 52 1.30 3 1.50 8 0.90 9 1.50 6 0.90 55 1.00
LOAD COMB 2048 1.3DL+1.3OP+1.5LL+0.9TC+1.5SL-0.9WY+1SS
51 1.30 52 1.30 3 1.50 8 0.90 9 1.50 6 -0.90 55 1.00
LOAD COMB 2049 1.3DL+1.3OP+1.5LL+1.5TE+0.9SL+0.9WX+1SS
51 1.30 52 1.30 3 1.50 7 1.50 9 0.90 5 0.90 55 1.00
LOAD COMB 2050 1.3DL+1.3OP+1.5LL+1.5TE+0.9SL-0.9WX+1SS
51 1.30 52 1.30 3 1.50 7 1.50 9 0.90 5 -0.90 55 1.00
LOAD COMB 2051 1.3DL+1.3OP+1.5LL+1.5TE+0.9SL+0.9WY+1SS
51 1.30 52 1.30 3 1.50 7 1.50 9 0.90 6 0.90 55 1.00
LOAD COMB 2052 1.3DL+1.3OP+1.5LL+1.5TE+0.9SL-0.9WY+1SS
51 1.30 52 1.30 3 1.50 7 1.50 9 0.90 6 -0.90 55 1.00
LOAD COMB 2053 1.3DL+1.3OP+1.5LL+1.5TC+0.9SL+0.9WX+1SS
51 1.30 52 1.30 3 1.50 8 1.50 9 0.90 5 0.90 55 1.00
LOAD COMB 2054 1.3DL+1.3OP+1.5LL+1.5TC+0.9SL-0.9WX+1SS
51 1.30 52 1.30 3 1.50 8 1.50 9 0.90 5 -0.90 55 1.00
LOAD COMB 2055 1.3DL+1.3OP+1.5LL+1.5TC+0.9SL+0.9WY+1SS
51 1.30 52 1.30 3 1.50 8 1.50 9 0.90 6 0.90 55 1.00
LOAD COMB 2056 1.3DL+1.3OP+1.5LL+1.5TC+0.9SL-0.9WY+1SS
51 1.30 52 1.30 3 1.50 8 1.50 9 0.90 6 -0.90 55 1.00
LOAD COMB 2057 1.3DL+1.3OP+1.5LL+0.9TE+0.9SL+1.5WX+1SS
51 1.30 52 1.30 3 1.50 7 0.90 9 0.90 5 1.50 55 1.00
LOAD COMB 2058 1.3DL+1.3OP+1.5LL+0.9TE+0.9SL-1.5WX+1SS
51 1.30 52 1.30 3 1.50 7 0.90 9 0.90 5 -1.50 55 1.00
LOAD COMB 2059 1.3DL+1.3OP+1.5LL+0.9TE+0.9SL+1.5WY+1SS
51 1.30 52 1.30 3 1.50 7 0.90 9 0.90 6 1.50 55 1.00
LOAD COMB 2060 1.3DL+1.3OP+1.5LL+0.9TE+0.9SL-1.5WY+1SS
51 1.30 52 1.30 3 1.50 7 0.90 9 0.90 6 -1.50 55 1.00
LOAD COMB 2061 1.3DL+1.3OP+1.5LL+0.9TC+0.9SL+1.5WX+1SS
51 1.30 52 1.30 3 1.50 8 0.90 9 0.90 5 1.50 55 1.00
LOAD COMB 2062 1.3DL+1.3OP+1.5LL+0.9TC+0.9SL-1.5WX+1SS
51 1.30 52 1.30 3 1.50 8 0.90 9 0.90 5 -1.50 55 1.00
LOAD COMB 2063 1.3DL+1.3OP+1.5LL+0.9TC+0.9SL+1.5WY+1SS

51 1.30 52 1.30 3 1.50 8 0.90 9 0.90 6 1.50 55 1.00
LOAD COMB 2064 1.3DL+1.3OP+1.5LL+0.9TC+0.9SL-1.5WY+1SS
51 1.30 52 1.30 3 1.50 8 0.90 9 0.90 6 -1.50 55 1.00
LOAD COMB 2065 1.3DL+1.3OP+1.5LL+0.9TE+0.9SL+0.9WX+1E1
51 1.30 52 1.30 3 1.50 7 0.90 9 0.90 5 0.90 53 1.00
LOAD COMB 2066 1.3DL+1.3OP+1.5LL+0.9TE+0.9SL-0.9WX+1E1
51 1.30 52 1.30 3 1.50 7 0.90 9 0.90 5 -0.90 53 1.00
LOAD COMB 2067 1.3DL+1.3OP+1.5LL+0.9TE+0.9SL+0.9WY+1E1
51 1.30 52 1.30 3 1.50 7 0.90 9 0.90 6 0.90 53 1.00
LOAD COMB 2068 1.3DL+1.3OP+1.5LL+0.9TE+0.9SL-0.9WY+1E1
51 1.30 52 1.30 3 1.50 7 0.90 9 0.90 6 -0.90 53 1.00
LOAD COMB 2069 1.3DL+1.3OP+1.5LL+0.9TC+0.9SL+0.9WX+1E1
51 1.30 52 1.30 3 1.50 8 0.90 9 0.90 5 0.90 53 1.00
LOAD COMB 2070 1.3DL+1.3OP+1.5LL+0.9TC+0.9SL-0.9WX+1E1
51 1.30 52 1.30 3 1.50 8 0.90 9 0.90 5 -0.90 53 1.00
LOAD COMB 2071 1.3DL+1.3OP+1.5LL+0.9TC+0.9SL+0.9WY+1E1
51 1.30 52 1.30 3 1.50 8 0.90 9 0.90 6 0.90 53 1.00
LOAD COMB 2072 1.3DL+1.3OP+1.5LL+0.9TC+0.9SL-0.9WY+1E1
51 1.30 52 1.30 3 1.50 8 0.90 9 0.90 6 -0.90 53 1.00
LOAD COMB 2073 1.3DL+1.3OP+1.5LL+0.9TE+1.5SL+0.9WX+1E1
51 1.30 52 1.30 3 1.50 7 0.90 9 1.50 5 0.90 53 1.00
LOAD COMB 2074 1.3DL+1.3OP+1.5LL+0.9TE+1.5SL-0.9WX+1E1
51 1.30 52 1.30 3 1.50 7 0.90 9 1.50 5 -0.90 53 1.00
LOAD COMB 2075 1.3DL+1.3OP+1.5LL+0.9TE+1.5SL+0.9WY+1E1
51 1.30 52 1.30 3 1.50 7 0.90 9 1.50 6 0.90 53 1.00
LOAD COMB 2076 1.3DL+1.3OP+1.5LL+0.9TE+1.5SL-0.9WY+1E1
51 1.30 52 1.30 3 1.50 7 0.90 9 1.50 6 -0.90 53 1.00
LOAD COMB 2077 1.3DL+1.3OP+1.5LL+0.9TC+1.5SL+0.9WX+1E1
51 1.30 52 1.30 3 1.50 8 0.90 9 1.50 5 0.90 53 1.00
LOAD COMB 2078 1.3DL+1.3OP+1.5LL+0.9TC+1.5SL-0.9WX+1E1
51 1.30 52 1.30 3 1.50 8 0.90 9 1.50 5 -0.90 53 1.00
LOAD COMB 2079 1.3DL+1.3OP+1.5LL+0.9TC+1.5SL+0.9WY+1E1
51 1.30 52 1.30 3 1.50 8 0.90 9 1.50 6 0.90 53 1.00
LOAD COMB 2080 1.3DL+1.3OP+1.5LL+0.9TC+1.5SL-0.9WY+1E1
51 1.30 52 1.30 3 1.50 8 0.90 9 1.50 6 -0.90 53 1.00
LOAD COMB 2081 1.3DL+1.3OP+1.5LL+1.5TE+0.9SL+0.9WX+1E1
51 1.30 52 1.30 3 1.50 7 1.50 9 0.90 5 0.90 53 1.00
LOAD COMB 2082 1.3DL+1.3OP+1.5LL+1.5TE+0.9SL-0.9WX+1E1
51 1.30 52 1.30 3 1.50 7 1.50 9 0.90 5 -0.90 53 1.00
LOAD COMB 2083 1.3DL+1.3OP+1.5LL+1.5TE+0.9SL+0.9WY+1E1
51 1.30 52 1.30 3 1.50 7 1.50 9 0.90 6 0.90 53 1.00
LOAD COMB 2084 1.3DL+1.3OP+1.5LL+1.5TE+0.9SL-0.9WY+1E1
51 1.30 52 1.30 3 1.50 7 1.50 9 0.90 6 -0.90 53 1.00
LOAD COMB 2085 1.3DL+1.3OP+1.5LL+1.5TC+0.9SL+0.9WX+1E1
51 1.30 52 1.30 3 1.50 8 1.50 9 0.90 5 0.90 53 1.00
LOAD COMB 2086 1.3DL+1.3OP+1.5LL+1.5TC+0.9SL-0.9WX+1E1
51 1.30 52 1.30 3 1.50 8 1.50 9 0.90 5 -0.90 53 1.00
LOAD COMB 2087 1.3DL+1.3OP+1.5LL+1.5TC+0.9SL+0.9WY+1E1
51 1.30 52 1.30 3 1.50 8 1.50 9 0.90 6 0.90 53 1.00
LOAD COMB 2088 1.3DL+1.3OP+1.5LL+1.5TC+0.9SL-0.9WY+1E1
51 1.30 52 1.30 3 1.50 8 1.50 9 0.90 6 -0.90 53 1.00
LOAD COMB 2089 1.3DL+1.3OP+1.5LL+0.9TE+0.9SL+1.5WX+1E1
51 1.30 52 1.30 3 1.50 7 0.90 9 0.90 5 1.50 53 1.00
LOAD COMB 2090 1.3DL+1.3OP+1.5LL+0.9TE+0.9SL-1.5WX+1E1
51 1.30 52 1.30 3 1.50 7 0.90 9 0.90 5 -1.50 53 1.00
LOAD COMB 2091 1.3DL+1.3OP+1.5LL+0.9TE+0.9SL+1.5WY+1E1
51 1.30 52 1.30 3 1.50 7 0.90 9 0.90 6 1.50 53 1.00
LOAD COMB 2092 1.3DL+1.3OP+1.5LL+0.9TE+0.9SL-1.5WY+1E1
51 1.30 52 1.30 3 1.50 7 0.90 9 0.90 6 -1.50 53 1.00
LOAD COMB 2093 1.3DL+1.3OP+1.5LL+0.9TC+0.9SL+1.5WX+1E1
51 1.30 52 1.30 3 1.50 8 0.90 9 0.90 5 1.50 53 1.00
LOAD COMB 2094 1.3DL+1.3OP+1.5LL+0.9TC+0.9SL-1.5WX+1E1
51 1.30 52 1.30 3 1.50 8 0.90 9 0.90 5 -1.50 53 1.00
LOAD COMB 2095 1.3DL+1.3OP+1.5LL+0.9TC+0.9SL+1.5WY+1E1
51 1.30 52 1.30 3 1.50 8 0.90 9 0.90 6 1.50 53 1.00
LOAD COMB 2096 1.3DL+1.3OP+1.5LL+0.9TC+0.9SL-1.5WY+1E1
51 1.30 52 1.30 3 1.50 8 0.90 9 0.90 6 -1.50 53 1.00
LOAD COMB 2097 1.3DL+1.3OP+1.5LL+0.9TE+0.9SL+0.9WX+1E2
51 1.30 52 1.30 3 1.50 7 0.90 9 0.90 5 0.90 54 1.00
LOAD COMB 2098 1.3DL+1.3OP+1.5LL+0.9TE+0.9SL-0.9WX+1E2

51 1.30 52 1.30 3 1.50 7 0.90 9 0.90 5 -0.90 54 1.00
LOAD COMB 2099 1.3DL+1.3OP+1.5LL+0.9TE+0.9SL+0.9WY+1E2
51 1.30 52 1.30 3 1.50 7 0.90 9 0.90 6 0.90 54 1.00
LOAD COMB 2100 1.3DL+1.3OP+1.5LL+0.9TE+0.9SL-0.9WY+1E2
51 1.30 52 1.30 3 1.50 7 0.90 9 0.90 6 -0.90 54 1.00
LOAD COMB 2101 1.3DL+1.3OP+1.5LL+0.9TC+0.9SL+0.9WX+1E2
51 1.30 52 1.30 3 1.50 8 0.90 9 0.90 5 0.90 54 1.00
LOAD COMB 2102 1.3DL+1.3OP+1.5LL+0.9TC+0.9SL-0.9WX+1E2
51 1.30 52 1.30 3 1.50 8 0.90 9 0.90 5 -0.90 54 1.00
LOAD COMB 2103 1.3DL+1.3OP+1.5LL+0.9TC+0.9SL+0.9WY+1E2
51 1.30 52 1.30 3 1.50 8 0.90 9 0.90 6 0.90 54 1.00
LOAD COMB 2104 1.3DL+1.3OP+1.5LL+0.9TC+0.9SL-0.9WY+1E2
51 1.30 52 1.30 3 1.50 8 0.90 9 0.90 6 -0.90 54 1.00
LOAD COMB 2105 1.3DL+1.3OP+1.5LL+0.9TE+1.5SL+0.9WX+1E2
51 1.30 52 1.30 3 1.50 7 0.90 9 1.50 5 0.90 54 1.00
LOAD COMB 2106 1.3DL+1.3OP+1.5LL+0.9TE+1.5SL-0.9WX+1E2
51 1.30 52 1.30 3 1.50 7 0.90 9 1.50 5 -0.90 54 1.00
LOAD COMB 2107 1.3DL+1.3OP+1.5LL+0.9TE+1.5SL+0.9WY+1E2
51 1.30 52 1.30 3 1.50 7 0.90 9 1.50 6 0.90 54 1.00
LOAD COMB 2108 1.3DL+1.3OP+1.5LL+0.9TE+1.5SL-0.9WY+1E2
51 1.30 52 1.30 3 1.50 7 0.90 9 1.50 6 -0.90 54 1.00
LOAD COMB 2109 1.3DL+1.3OP+1.5LL+0.9TC+1.5SL+0.9WX+1E2
51 1.30 52 1.30 3 1.50 8 0.90 9 1.50 5 0.90 54 1.00
LOAD COMB 2110 1.3DL+1.3OP+1.5LL+0.9TC+1.5SL-0.9WX+1E2
51 1.30 52 1.30 3 1.50 8 0.90 9 1.50 5 -0.90 54 1.00
LOAD COMB 2111 1.3DL+1.3OP+1.5LL+0.9TC+1.5SL+0.9WY+1E2
51 1.30 52 1.30 3 1.50 8 0.90 9 1.50 6 0.90 54 1.00
LOAD COMB 2112 1.3DL+1.3OP+1.5LL+0.9TC+1.5SL-0.9WY+1E2
51 1.30 52 1.30 3 1.50 8 0.90 9 1.50 6 -0.90 54 1.00
LOAD COMB 2113 1.3DL+1.3OP+1.5LL+1.5TE+0.9SL+0.9WX+1E2
51 1.30 52 1.30 3 1.50 7 1.50 9 0.90 5 0.90 54 1.00
LOAD COMB 2114 1.3DL+1.3OP+1.5LL+1.5TE+0.9SL-0.9WX+1E2
51 1.30 52 1.30 3 1.50 7 1.50 9 0.90 5 -0.90 54 1.00
LOAD COMB 2115 1.3DL+1.3OP+1.5LL+1.5TE+0.9SL+0.9WY+1E2
51 1.30 52 1.30 3 1.50 7 1.50 9 0.90 6 0.90 54 1.00
LOAD COMB 2116 1.3DL+1.3OP+1.5LL+1.5TE+0.9SL-0.9WY+1E2
51 1.30 52 1.30 3 1.50 7 1.50 9 0.90 6 -0.90 54 1.00
LOAD COMB 2117 1.3DL+1.3OP+1.5LL+1.5TC+0.9SL+0.9WX+1E2
51 1.30 52 1.30 3 1.50 8 1.50 9 0.90 5 0.90 54 1.00
LOAD COMB 2118 1.3DL+1.3OP+1.5LL+1.5TC+0.9SL-0.9WX+1E2
51 1.30 52 1.30 3 1.50 8 1.50 9 0.90 5 -0.90 54 1.00
LOAD COMB 2119 1.3DL+1.3OP+1.5LL+1.5TC+0.9SL+0.9WY+1E2
51 1.30 52 1.30 3 1.50 8 1.50 9 0.90 6 0.90 54 1.00
LOAD COMB 2120 1.3DL+1.3OP+1.5LL+1.5TC+0.9SL-0.9WY+1E2
51 1.30 52 1.30 3 1.50 8 1.50 9 0.90 6 -0.90 54 1.00
LOAD COMB 2121 1.3DL+1.3OP+1.5LL+0.9TE+0.9SL+1.5WX+1E2
51 1.30 52 1.30 3 1.50 7 0.90 9 0.90 5 1.50 54 1.00
LOAD COMB 2122 1.3DL+1.3OP+1.5LL+0.9TE+0.9SL-1.5WX+1E2
51 1.30 52 1.30 3 1.50 7 0.90 9 0.90 5 -1.50 54 1.00
LOAD COMB 2123 1.3DL+1.3OP+1.5LL+0.9TE+0.9SL+1.5WY+1E2
51 1.30 52 1.30 3 1.50 7 0.90 9 0.90 6 1.50 54 1.00
LOAD COMB 2124 1.3DL+1.3OP+1.5LL+0.9TE+0.9SL-1.5WY+1E2
51 1.30 52 1.30 3 1.50 7 0.90 9 0.90 6 -1.50 54 1.00
LOAD COMB 2125 1.3DL+1.3OP+1.5LL+0.9TC+0.9SL+1.5WX+1E2
51 1.30 52 1.30 3 1.50 8 0.90 9 0.90 5 1.50 54 1.00
LOAD COMB 2126 1.3DL+1.3OP+1.5LL+0.9TC+0.9SL-1.5WX+1E2
51 1.30 52 1.30 3 1.50 8 0.90 9 0.90 5 -1.50 54 1.00
LOAD COMB 2127 1.3DL+1.3OP+1.5LL+0.9TC+0.9SL+1.5WY+1E2
51 1.30 52 1.30 3 1.50 8 0.90 9 0.90 6 1.50 54 1.00
LOAD COMB 2128 1.3DL+1.3OP+1.5LL+0.9TC+0.9SL-1.5WY+1E2
51 1.30 52 1.30 3 1.50 8 0.90 9 0.90 6 -1.50 54 1.00
LOAD COMB 2129 1DL+1.3OP+0.6LL+1EXD+0.3EZD
51 1.00 52 1.30 3 0.60 20 1.00 21 0.30
LOAD COMB 2130 1DL+1.3OP+0.6LL-1EXD+0.3EZD
51 1.00 52 1.30 3 0.60 20 -1.00 21 0.30
LOAD COMB 2131 1DL+1.3OP+0.6LL+1EXD-0.3EZD
51 1.00 52 1.30 3 0.60 20 1.00 21 -0.30
LOAD COMB 2132 1DL+1.3OP+0.6LL-1EXD-0.3EZD
51 1.00 52 1.30 3 0.60 20 -1.00 21 -0.30
LOAD COMB 2133 1DL+1.3OP+0.6LL+0.3EXD+1EZD

51 1.00 52 1.30 3 0.60 20 0.30 21 1.00
LOAD COMB 2134 1DL+1.3OP+0.6LL+0.3EXD-1EZD
51 1.00 52 1.30 3 0.60 20 0.30 21 -1.00
LOAD COMB 2135 1DL+1.3OP+0.6LL-0.3EXD+1EZD
51 1.00 52 1.30 3 0.60 20 -0.30 21 1.00
LOAD COMB 2136 1DL+1.3OP+0.6LL-0.3EXD-1EZD
51 1.00 52 1.30 3 0.60 20 -0.30 21 -1.00
LOAD COMB 2137 1.3DL-3.9OP+1.5LL+0.9TE+0.9SL+0.9WX
51 1.30 52 -3.90 3 1.50 7 0.90 9 0.90 5 0.90
LOAD COMB 2138 1.3DL-3.9OP+1.5LL+0.9TE+0.9SL-0.9WX
51 1.30 52 -3.90 3 1.50 7 0.90 9 0.90 5 -0.90
LOAD COMB 2139 1.3DL-3.9OP+1.5LL+0.9TE+0.9SL+0.9WY
51 1.30 52 -3.90 3 1.50 7 0.90 9 0.90 6 0.90
LOAD COMB 2140 1.3DL-3.9OP+1.5LL+0.9TE+0.9SL-0.9WY
51 1.30 52 -3.90 3 1.50 7 0.90 9 0.90 6 -0.90
LOAD COMB 2141 1.3DL-3.9OP+1.5LL+0.9TC+0.9SL+0.9WX
51 1.30 52 -3.90 3 1.50 8 0.90 9 0.90 5 0.90
LOAD COMB 2142 1.3DL-3.9OP+1.5LL+0.9TC+0.9SL-0.9WX
51 1.30 52 -3.90 3 1.50 8 0.90 9 0.90 5 -0.90
LOAD COMB 2143 1.3DL-3.9OP+1.5LL+0.9TC+0.9SL+0.9WY
51 1.30 52 -3.90 3 1.50 8 0.90 9 0.90 6 0.90
LOAD COMB 2144 1.3DL-3.9OP+1.5LL+0.9TC+0.9SL-0.9WY
51 1.30 52 -3.90 3 1.50 8 0.90 9 0.90 6 -0.90
LOAD COMB 2145 1.3DL-3.9OP+1.5LL+0.9TE+1.5SL+0.9WX
51 1.30 52 -3.90 3 1.50 7 0.90 9 1.50 5 0.90
LOAD COMB 2146 1.3DL-3.9OP+1.5LL+0.9TE+1.5SL-0.9WX
51 1.30 52 -3.90 3 1.50 7 0.90 9 1.50 5 -0.90
LOAD COMB 2147 1.3DL-3.9OP+1.5LL+0.9TE+1.5SL+0.9WY
51 1.30 52 -3.90 3 1.50 7 0.90 9 1.50 6 0.90
LOAD COMB 2148 1.3DL-3.9OP+1.5LL+0.9TE+1.5SL-0.9WY
51 1.30 52 -3.90 3 1.50 7 0.90 9 1.50 6 -0.90
LOAD COMB 2149 1.3DL-3.9OP+1.5LL+0.9TC+1.5SL+0.9WX
51 1.30 52 -3.90 3 1.50 8 0.90 9 1.50 5 0.90
LOAD COMB 2150 1.3DL-3.9OP+1.5LL+0.9TC+1.5SL-0.9WX
51 1.30 52 -3.90 3 1.50 8 0.90 9 1.50 5 -0.90
LOAD COMB 2151 1.3DL-3.9OP+1.5LL+0.9TC+1.5SL+0.9WY
51 1.30 52 -3.90 3 1.50 8 0.90 9 1.50 6 0.90
LOAD COMB 2152 1.3DL-3.9OP+1.5LL+0.9TC+1.5SL-0.9WY
51 1.30 52 -3.90 3 1.50 8 0.90 9 1.50 6 -0.90
LOAD COMB 2153 1.3DL-3.9OP+1.5LL+1.5TE+0.9SL+0.9WX
51 1.30 52 -3.90 3 1.50 7 1.50 9 0.90 5 0.90
LOAD COMB 2154 1.3DL-3.9OP+1.5LL+1.5TE+0.9SL-0.9WX
51 1.30 52 -3.90 3 1.50 7 1.50 9 0.90 5 -0.90
LOAD COMB 2155 1.3DL-3.9OP+1.5LL+1.5TE+0.9SL+0.9WY
51 1.30 52 -3.90 3 1.50 7 1.50 9 0.90 6 0.90
LOAD COMB 2156 1.3DL-3.9OP+1.5LL+1.5TE+0.9SL-0.9WY
51 1.30 52 -3.90 3 1.50 7 1.50 9 0.90 6 -0.90
LOAD COMB 2157 1.3DL-3.9OP+1.5LL+1.5TC+0.9SL+0.9WX
51 1.30 52 -3.90 3 1.50 8 1.50 9 0.90 5 0.90
LOAD COMB 2158 1.3DL-3.9OP+1.5LL+1.5TC+0.9SL-0.9WX
51 1.30 52 -3.90 3 1.50 8 1.50 9 0.90 5 -0.90
LOAD COMB 2159 1.3DL-3.9OP+1.5LL+1.5TC+0.9SL+0.9WY
51 1.30 52 -3.90 3 1.50 8 1.50 9 0.90 6 0.90
LOAD COMB 2160 1.3DL-3.9OP+1.5LL+1.5TC+0.9SL-0.9WY
51 1.30 52 -3.90 3 1.50 8 1.50 9 0.90 6 -0.90
LOAD COMB 2161 1.3DL-3.9OP+1.5LL+0.9TE+0.9SL+1.5WX
51 1.30 52 -3.90 3 1.50 7 0.90 9 0.90 5 1.50
LOAD COMB 2162 1.3DL-3.9OP+1.5LL+0.9TE+0.9SL-1.5WX
51 1.30 52 -3.90 3 1.50 7 0.90 9 0.90 5 -1.50
LOAD COMB 2163 1.3DL-3.9OP+1.5LL+0.9TE+0.9SL+1.5WY
51 1.30 52 -3.90 3 1.50 7 0.90 9 0.90 6 1.50
LOAD COMB 2164 1.3DL-3.9OP+1.5LL+0.9TE+0.9SL-1.5WY
51 1.30 52 -3.90 3 1.50 7 0.90 9 0.90 6 -1.50
LOAD COMB 2165 1.3DL-3.9OP+1.5LL+0.9TC+0.9SL+1.5WX
51 1.30 52 -3.90 3 1.50 8 0.90 9 0.90 5 1.50
LOAD COMB 2166 1.3DL-3.9OP+1.5LL+0.9TC+0.9SL-1.5WX
51 1.30 52 -3.90 3 1.50 8 0.90 9 0.90 5 -1.50
LOAD COMB 2167 1.3DL-3.9OP+1.5LL+0.9TC+0.9SL+1.5WY
51 1.30 52 -3.90 3 1.50 8 0.90 9 0.90 6 1.50
LOAD COMB 2168 1.3DL-3.9OP+1.5LL+0.9TC+0.9SL-1.5WY

51 1.30 52 -3.90 3 1.50 8 0.90 9 0.90 6 -1.50
LOAD COMB 2169 1.3DL-1.3OP+1.5LL+0.9TE+0.9SL+0.9WX+1SS
51 1.30 52 -1.30 3 1.50 7 0.90 9 0.90 5 0.90 55 1.00
LOAD COMB 2170 1.3DL-1.3OP+1.5LL+0.9TE+0.9SL-0.9WX+1SS
51 1.30 52 -1.30 3 1.50 7 0.90 9 0.90 5 -0.90 55 1.00
LOAD COMB 2171 1.3DL-1.3OP+1.5LL+0.9TE+0.9SL+0.9WY+1SS
51 1.30 52 -1.30 3 1.50 7 0.90 9 0.90 6 0.90 55 1.00
LOAD COMB 2172 1.3DL-1.3OP+1.5LL+0.9TE+0.9SL-0.9WY+1SS
51 1.30 52 -1.30 3 1.50 7 0.90 9 0.90 6 -0.90 55 1.00
LOAD COMB 2173 1.3DL-1.3OP+1.5LL+0.9TC+0.9SL+0.9WX+1SS
51 1.30 52 -1.30 3 1.50 8 0.90 9 0.90 5 0.90 55 1.00
LOAD COMB 2174 1.3DL-1.3OP+1.5LL+0.9TC+0.9SL-0.9WX+1SS
51 1.30 52 -1.30 3 1.50 8 0.90 9 0.90 5 -0.90 55 1.00
LOAD COMB 2175 1.3DL-1.3OP+1.5LL+0.9TC+0.9SL+0.9WY+1SS
51 1.30 52 -1.30 3 1.50 8 0.90 9 0.90 6 0.90 55 1.00
LOAD COMB 2176 1.3DL-1.3OP+1.5LL+0.9TC+0.9SL-0.9WY+1SS
51 1.30 52 -1.30 3 1.50 8 0.90 9 0.90 6 -0.90 55 1.00
LOAD COMB 2177 1.3DL-1.3OP+1.5LL+0.9TE+1.5SL+0.9WX+1SS
51 1.30 52 -1.30 3 1.50 7 0.90 9 1.50 5 0.90 55 1.00
LOAD COMB 2178 1.3DL-1.3OP+1.5LL+0.9TE+1.5SL-0.9WX+1SS
51 1.30 52 -1.30 3 1.50 7 0.90 9 1.50 5 -0.90 55 1.00
LOAD COMB 2179 1.3DL-1.3OP+1.5LL+0.9TE+1.5SL+0.9WY+1SS
51 1.30 52 -1.30 3 1.50 7 0.90 9 1.50 6 0.90 55 1.00
LOAD COMB 2180 1.3DL-1.3OP+1.5LL+0.9TE+1.5SL-0.9WY+1SS
51 1.30 52 -1.30 3 1.50 7 0.90 9 1.50 6 -0.90 55 1.00
LOAD COMB 2181 1.3DL-1.3OP+1.5LL+0.9TC+1.5SL+0.9WX+1SS
51 1.30 52 -1.30 3 1.50 8 0.90 9 1.50 5 0.90 55 1.00
LOAD COMB 2182 1.3DL-1.3OP+1.5LL+0.9TC+1.5SL-0.9WX+1SS
51 1.30 52 -1.30 3 1.50 8 0.90 9 1.50 5 -0.90 55 1.00
LOAD COMB 2183 1.3DL-1.3OP+1.5LL+0.9TC+1.5SL+0.9WY+1SS
51 1.30 52 -1.30 3 1.50 8 0.90 9 1.50 6 0.90 55 1.00
LOAD COMB 2184 1.3DL-1.3OP+1.5LL+0.9TC+1.5SL-0.9WY+1SS
51 1.30 52 -1.30 3 1.50 8 0.90 9 1.50 6 -0.90 55 1.00
LOAD COMB 2185 1.3DL-1.3OP+1.5LL+1.5TE+0.9SL+0.9WX+1SS
51 1.30 52 -1.30 3 1.50 7 1.50 9 0.90 5 0.90 55 1.00
LOAD COMB 2186 1.3DL-1.3OP+1.5LL+1.5TE+0.9SL-0.9WX+1SS
51 1.30 52 -1.30 3 1.50 7 1.50 9 0.90 5 -0.90 55 1.00
LOAD COMB 2187 1.3DL-1.3OP+1.5LL+1.5TE+0.9SL+0.9WY+1SS
51 1.30 52 -1.30 3 1.50 7 1.50 9 0.90 6 0.90 55 1.00
LOAD COMB 2188 1.3DL-1.3OP+1.5LL+1.5TE+0.9SL-0.9WY+1SS
51 1.30 52 -1.30 3 1.50 7 1.50 9 0.90 6 -0.90 55 1.00
LOAD COMB 2189 1.3DL-1.3OP+1.5LL+1.5TC+0.9SL+0.9WX+1SS
51 1.30 52 -1.30 3 1.50 8 1.50 9 0.90 5 0.90 55 1.00
LOAD COMB 2190 1.3DL-1.3OP+1.5LL+1.5TC+0.9SL-0.9WX+1SS
51 1.30 52 -1.30 3 1.50 8 1.50 9 0.90 5 -0.90 55 1.00
LOAD COMB 2191 1.3DL-1.3OP+1.5LL+1.5TC+0.9SL+0.9WY+1SS
51 1.30 52 -1.30 3 1.50 8 1.50 9 0.90 6 0.90 55 1.00
LOAD COMB 2192 1.3DL-1.3OP+1.5LL+1.5TC+0.9SL-0.9WY+1SS
51 1.30 52 -1.30 3 1.50 8 1.50 9 0.90 6 -0.90 55 1.00
LOAD COMB 2193 1.3DL-1.3OP+1.5LL+0.9TE+0.9SL+1.5WX+1SS
51 1.30 52 -1.30 3 1.50 7 0.90 9 0.90 5 1.50 55 1.00
LOAD COMB 2194 1.3DL-1.3OP+1.5LL+0.9TE+0.9SL-1.5WX+1SS
51 1.30 52 -1.30 3 1.50 7 0.90 9 0.90 5 -1.50 55 1.00
LOAD COMB 2195 1.3DL-1.3OP+1.5LL+0.9TE+0.9SL+1.5WY+1SS
51 1.30 52 -1.30 3 1.50 7 0.90 9 0.90 6 1.50 55 1.00
LOAD COMB 2196 1.3DL-1.3OP+1.5LL+0.9TE+0.9SL-1.5WY+1SS
51 1.30 52 -1.30 3 1.50 7 0.90 9 0.90 6 -1.50 55 1.00
LOAD COMB 2197 1.3DL-1.3OP+1.5LL+0.9TC+0.9SL+1.5WX+1SS
51 1.30 52 -1.30 3 1.50 8 0.90 9 0.90 5 1.50 55 1.00
LOAD COMB 2198 1.3DL-1.3OP+1.5LL+0.9TC+0.9SL-1.5WX+1SS
51 1.30 52 -1.30 3 1.50 8 0.90 9 0.90 5 -1.50 55 1.00
LOAD COMB 2199 1.3DL-1.3OP+1.5LL+0.9TC+0.9SL+1.5WY+1SS
51 1.30 52 -1.30 3 1.50 8 0.90 9 0.90 6 1.50 55 1.00
LOAD COMB 2200 1.3DL-1.3OP+1.5LL+0.9TC+0.9SL-1.5WY+1SS
51 1.30 52 -1.30 3 1.50 8 0.90 9 0.90 6 -1.50 55 1.00
LOAD COMB 2201 1.3DL-1.3OP+1.5LL+0.9TE+0.9SL+0.9WX+1E1
51 1.30 52 -1.30 3 1.50 7 0.90 9 0.90 5 0.90 53 1.00
LOAD COMB 2202 1.3DL-1.3OP+1.5LL+0.9TE+0.9SL-0.9WX+1E1
51 1.30 52 -1.30 3 1.50 7 0.90 9 0.90 5 -0.90 53 1.00
LOAD COMB 2203 1.3DL-1.3OP+1.5LL+0.9TE+0.9SL+0.9WY+1E1

51 1.30 52 -1.30 3 1.50 7 0.90 9 0.90 6 0.90 53 1.00
LOAD COMB 2204 1.3DL-1.3OP+1.5LL+0.9TE+0.9SL-0.9WY+1E1
51 1.30 52 -1.30 3 1.50 7 0.90 9 0.90 6 -0.90 53 1.00
LOAD COMB 2205 1.3DL-1.3OP+1.5LL+0.9TC+0.9SL+0.9WX+1E1
51 1.30 52 -1.30 3 1.50 8 0.90 9 0.90 5 0.90 53 1.00
LOAD COMB 2206 1.3DL-1.3OP+1.5LL+0.9TC+0.9SL-0.9WX+1E1
51 1.30 52 -1.30 3 1.50 8 0.90 9 0.90 5 -0.90 53 1.00
LOAD COMB 2207 1.3DL-1.3OP+1.5LL+0.9TC+0.9SL+0.9WY+1E1
51 1.30 52 -1.30 3 1.50 8 0.90 9 0.90 6 0.90 53 1.00
LOAD COMB 2208 1.3DL-1.3OP+1.5LL+0.9TC+0.9SL-0.9WY+1E1
51 1.30 52 -1.30 3 1.50 8 0.90 9 0.90 6 -0.90 53 1.00
LOAD COMB 2209 1.3DL-1.3OP+1.5LL+0.9TE+1.5SL+0.9WX+1E1
51 1.30 52 -1.30 3 1.50 7 0.90 9 1.50 5 0.90 53 1.00
LOAD COMB 2210 1.3DL-1.3OP+1.5LL+0.9TE+1.5SL-0.9WX+1E1
51 1.30 52 -1.30 3 1.50 7 0.90 9 1.50 5 -0.90 53 1.00
LOAD COMB 2211 1.3DL-1.3OP+1.5LL+0.9TE+1.5SL+0.9WY+1E1
51 1.30 52 -1.30 3 1.50 7 0.90 9 1.50 6 0.90 53 1.00
LOAD COMB 2212 1.3DL-1.3OP+1.5LL+0.9TE+1.5SL-0.9WY+1E1
51 1.30 52 -1.30 3 1.50 7 0.90 9 1.50 6 -0.90 53 1.00
LOAD COMB 2213 1.3DL-1.3OP+1.5LL+0.9TC+1.5SL+0.9WX+1E1
51 1.30 52 -1.30 3 1.50 8 0.90 9 1.50 5 0.90 53 1.00
LOAD COMB 2214 1.3DL-1.3OP+1.5LL+0.9TC+1.5SL-0.9WX+1E1
51 1.30 52 -1.30 3 1.50 8 0.90 9 1.50 5 -0.90 53 1.00
LOAD COMB 2215 1.3DL-1.3OP+1.5LL+0.9TC+1.5SL+0.9WY+1E1
51 1.30 52 -1.30 3 1.50 8 0.90 9 1.50 6 0.90 53 1.00
LOAD COMB 2216 1.3DL-1.3OP+1.5LL+0.9TC+1.5SL-0.9WY+1E1
51 1.30 52 -1.30 3 1.50 8 0.90 9 1.50 6 -0.90 53 1.00
LOAD COMB 2217 1.3DL-1.3OP+1.5LL+1.5TE+0.9SL+0.9WX+1E1
51 1.30 52 -1.30 3 1.50 7 1.50 9 0.90 5 0.90 53 1.00
LOAD COMB 2218 1.3DL-1.3OP+1.5LL+1.5TE+0.9SL-0.9WX+1E1
51 1.30 52 -1.30 3 1.50 7 1.50 9 0.90 5 -0.90 53 1.00
LOAD COMB 2219 1.3DL-1.3OP+1.5LL+1.5TE+0.9SL+0.9WY+1E1
51 1.30 52 -1.30 3 1.50 7 1.50 9 0.90 6 0.90 53 1.00
LOAD COMB 2220 1.3DL-1.3OP+1.5LL+1.5TE+0.9SL-0.9WY+1E1
51 1.30 52 -1.30 3 1.50 7 1.50 9 0.90 6 -0.90 53 1.00
LOAD COMB 2221 1.3DL-1.3OP+1.5LL+1.5TC+0.9SL+0.9WX+1E1
51 1.30 52 -1.30 3 1.50 8 1.50 9 0.90 5 0.90 53 1.00
LOAD COMB 2222 1.3DL-1.3OP+1.5LL+1.5TC+0.9SL-0.9WX+1E1
51 1.30 52 -1.30 3 1.50 8 1.50 9 0.90 5 -0.90 53 1.00
LOAD COMB 2223 1.3DL-1.3OP+1.5LL+1.5TC+0.9SL+0.9WY+1E1
51 1.30 52 -1.30 3 1.50 8 1.50 9 0.90 6 0.90 53 1.00
LOAD COMB 2224 1.3DL-1.3OP+1.5LL+1.5TC+0.9SL-0.9WY+1E1
51 1.30 52 -1.30 3 1.50 8 1.50 9 0.90 6 -0.90 53 1.00
LOAD COMB 2225 1.3DL-1.3OP+1.5LL+0.9TE+0.9SL+1.5WX+1E1
51 1.30 52 -1.30 3 1.50 7 0.90 9 0.90 5 1.50 53 1.00
LOAD COMB 2226 1.3DL-1.3OP+1.5LL+0.9TE+0.9SL-1.5WX+1E1
51 1.30 52 -1.30 3 1.50 7 0.90 9 0.90 5 -1.50 53 1.00
LOAD COMB 2227 1.3DL-1.3OP+1.5LL+0.9TE+0.9SL+1.5WY+1E1
51 1.30 52 -1.30 3 1.50 7 0.90 9 0.90 6 1.50 53 1.00
LOAD COMB 2228 1.3DL-1.3OP+1.5LL+0.9TE+0.9SL-1.5WY+1E1
51 1.30 52 -1.30 3 1.50 7 0.90 9 0.90 6 -1.50 53 1.00
LOAD COMB 2229 1.3DL-1.3OP+1.5LL+0.9TC+0.9SL+1.5WX+1E1
51 1.30 52 -1.30 3 1.50 8 0.90 9 0.90 5 1.50 53 1.00
LOAD COMB 2230 1.3DL-1.3OP+1.5LL+0.9TC+0.9SL-1.5WX+1E1
51 1.30 52 -1.30 3 1.50 8 0.90 9 0.90 5 -1.50 53 1.00
LOAD COMB 2231 1.3DL-1.3OP+1.5LL+0.9TC+0.9SL+1.5WY+1E1
51 1.30 52 -1.30 3 1.50 8 0.90 9 0.90 6 1.50 53 1.00
LOAD COMB 2232 1.3DL-1.3OP+1.5LL+0.9TC+0.9SL-1.5WY+1E1
51 1.30 52 -1.30 3 1.50 8 0.90 9 0.90 6 -1.50 53 1.00
LOAD COMB 2233 1.3DL-1.3OP+1.5LL+0.9TE+0.9SL+0.9WX+1E2
51 1.30 52 -1.30 3 1.50 7 0.90 9 0.90 5 0.90 54 1.00
LOAD COMB 2234 1.3DL-1.3OP+1.5LL+0.9TE+0.9SL-0.9WX+1E2
51 1.30 52 -1.30 3 1.50 7 0.90 9 0.90 5 -0.90 54 1.00
LOAD COMB 2235 1.3DL-1.3OP+1.5LL+0.9TE+0.9SL+0.9WY+1E2
51 1.30 52 -1.30 3 1.50 7 0.90 9 0.90 6 0.90 54 1.00
LOAD COMB 2236 1.3DL-1.3OP+1.5LL+0.9TE+0.9SL-0.9WY+1E2
51 1.30 52 -1.30 3 1.50 7 0.90 9 0.90 6 -0.90 54 1.00
LOAD COMB 2237 1.3DL-1.3OP+1.5LL+0.9TC+0.9SL+0.9WX+1E2
51 1.30 52 -1.30 3 1.50 8 0.90 9 0.90 5 0.90 54 1.00
LOAD COMB 2238 1.3DL-1.3OP+1.5LL+0.9TC+0.9SL-0.9WX+1E2

51 1.30 52 -1.30 3 1.50 8 0.90 9 0.90 5 -0.90 54 1.00
LOAD COMB 2239 1.3DL-1.3OP+1.5LL+0.9TC+0.9SL+0.9WY+1E2
51 1.30 52 -1.30 3 1.50 8 0.90 9 0.90 6 0.90 54 1.00
LOAD COMB 2240 1.3DL-1.3OP+1.5LL+0.9TC+0.9SL-0.9WY+1E2
51 1.30 52 -1.30 3 1.50 8 0.90 9 0.90 6 -0.90 54 1.00
LOAD COMB 2241 1.3DL-1.3OP+1.5LL+0.9TE+1.5SL+0.9WX+1E2
51 1.30 52 -1.30 3 1.50 7 0.90 9 1.50 5 0.90 54 1.00
LOAD COMB 2242 1.3DL-1.3OP+1.5LL+0.9TE+1.5SL-0.9WX+1E2
51 1.30 52 -1.30 3 1.50 7 0.90 9 1.50 5 -0.90 54 1.00
LOAD COMB 2243 1.3DL-1.3OP+1.5LL+0.9TE+1.5SL+0.9WY+1E2
51 1.30 52 -1.30 3 1.50 7 0.90 9 1.50 6 0.90 54 1.00
LOAD COMB 2244 1.3DL-1.3OP+1.5LL+0.9TE+1.5SL-0.9WY+1E2
51 1.30 52 -1.30 3 1.50 7 0.90 9 1.50 6 -0.90 54 1.00
LOAD COMB 2245 1.3DL-1.3OP+1.5LL+0.9TC+1.5SL+0.9WX+1E2
51 1.30 52 -1.30 3 1.50 8 0.90 9 1.50 5 0.90 54 1.00
LOAD COMB 2246 1.3DL-1.3OP+1.5LL+0.9TC+1.5SL-0.9WX+1E2
51 1.30 52 -1.30 3 1.50 8 0.90 9 1.50 5 -0.90 54 1.00
LOAD COMB 2247 1.3DL-1.3OP+1.5LL+0.9TC+1.5SL+0.9WY+1E2
51 1.30 52 -1.30 3 1.50 8 0.90 9 1.50 6 0.90 54 1.00
LOAD COMB 2248 1.3DL-1.3OP+1.5LL+0.9TC+1.5SL-0.9WY+1E2
51 1.30 52 -1.30 3 1.50 8 0.90 9 1.50 6 -0.90 54 1.00
LOAD COMB 2249 1.3DL-1.3OP+1.5LL+1.5TE+0.9SL+0.9WX+1E2
51 1.30 52 -1.30 3 1.50 7 1.50 9 0.90 5 0.90 54 1.00
LOAD COMB 2250 1.3DL-1.3OP+1.5LL+1.5TE+0.9SL-0.9WX+1E2
51 1.30 52 -1.30 3 1.50 7 1.50 9 0.90 5 -0.90 54 1.00
LOAD COMB 2251 1.3DL-1.3OP+1.5LL+1.5TE+0.9SL+0.9WY+1E2
51 1.30 52 -1.30 3 1.50 7 1.50 9 0.90 6 0.90 54 1.00
LOAD COMB 2252 1.3DL-1.3OP+1.5LL+1.5TE+0.9SL-0.9WY+1E2
51 1.30 52 -1.30 3 1.50 7 1.50 9 0.90 6 -0.90 54 1.00
LOAD COMB 2253 1.3DL-1.3OP+1.5LL+1.5TC+0.9SL+0.9WX+1E2
51 1.30 52 -1.30 3 1.50 8 1.50 9 0.90 5 0.90 54 1.00
LOAD COMB 2254 1.3DL-1.3OP+1.5LL+1.5TC+0.9SL-0.9WX+1E2
51 1.30 52 -1.30 3 1.50 8 1.50 9 0.90 5 -0.90 54 1.00
LOAD COMB 2255 1.3DL-1.3OP+1.5LL+1.5TC+0.9SL+0.9WY+1E2
51 1.30 52 -1.30 3 1.50 8 1.50 9 0.90 6 0.90 54 1.00
LOAD COMB 2256 1.3DL-1.3OP+1.5LL+1.5TC+0.9SL-0.9WY+1E2
51 1.30 52 -1.30 3 1.50 8 1.50 9 0.90 6 -0.90 54 1.00
LOAD COMB 2257 1.3DL-1.3OP+1.5LL+0.9TE+0.9SL+1.5WX+1E2
51 1.30 52 -1.30 3 1.50 7 0.90 9 0.90 5 1.50 54 1.00
LOAD COMB 2258 1.3DL-1.3OP+1.5LL+0.9TE+0.9SL-1.5WX+1E2
51 1.30 52 -1.30 3 1.50 7 0.90 9 0.90 5 -1.50 54 1.00
LOAD COMB 2259 1.3DL-1.3OP+1.5LL+0.9TE+0.9SL+1.5WY+1E2
51 1.30 52 -1.30 3 1.50 7 0.90 9 0.90 6 1.50 54 1.00
LOAD COMB 2260 1.3DL-1.3OP+1.5LL+0.9TE+0.9SL-1.5WY+1E2
51 1.30 52 -1.30 3 1.50 7 0.90 9 0.90 6 -1.50 54 1.00
LOAD COMB 2261 1.3DL-1.3OP+1.5LL+0.9TC+0.9SL+1.5WX+1E2
51 1.30 52 -1.30 3 1.50 8 0.90 9 0.90 5 1.50 54 1.00
LOAD COMB 2262 1.3DL-1.3OP+1.5LL+0.9TC+0.9SL-1.5WX+1E2
51 1.30 52 -1.30 3 1.50 8 0.90 9 0.90 5 -1.50 54 1.00
LOAD COMB 2263 1.3DL-1.3OP+1.5LL+0.9TC+0.9SL+1.5WY+1E2
51 1.30 52 -1.30 3 1.50 8 0.90 9 0.90 6 1.50 54 1.00
LOAD COMB 2264 1.3DL-1.3OP+1.5LL+0.9TC+0.9SL-1.5WY+1E2
51 1.30 52 -1.30 3 1.50 8 0.90 9 0.90 6 -1.50 54 1.00
LOAD COMB 2265 1DL-1.3OP+0.6LL+1EXD+0.3EZD
51 1.00 52 -1.30 3 0.60 20 1.00 21 0.30
LOAD COMB 2266 1DL-1.3OP+0.6LL-1EXD+0.3EZD
51 1.00 52 -1.30 3 0.60 20 -1.00 21 0.30
LOAD COMB 2267 1DL-1.3OP+0.6LL+1EXD-0.3EZD
51 1.00 52 -1.30 3 0.60 20 1.00 21 -0.30
LOAD COMB 2268 1DL-1.3OP+0.6LL-1EXD-0.3EZD
51 1.00 52 -1.30 3 0.60 20 -1.00 21 -0.30
LOAD COMB 2269 1DL-1.3OP+0.6LL+0.3EXD+1EZD
51 1.00 52 -1.30 3 0.60 20 0.30 21 1.00
LOAD COMB 2270 1DL-1.3OP+0.6LL+0.3EXD-1EZD
51 1.00 52 -1.30 3 0.60 20 0.30 21 -1.00
LOAD COMB 2271 1DL-1.3OP+0.6LL-0.3EXD+1EZD
51 1.00 52 -1.30 3 0.60 20 -0.30 21 1.00
LOAD COMB 2272 1DL-1.3OP+0.6LL-0.3EXD-1EZD
51 1.00 52 -1.30 3 0.60 20 -0.30 21 -1.00

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The piles provide additional spring and damping contributions to the system, so some means is necessary to incorporate the significant properties of the two materials into equivalent springs and damping factors. When we do this we can then use Eq. (20-4*a*) to obtain the solution (or the coupling concepts) for that vibration mode.

There are few theories and even fewer reported data from field performance studies on full-scale dynamically loaded bases supported by pile foundations. For this reason the theories are substantially uncertain; however, rational estimates are better than simply guessing at the response.

It is generally accepted that using piles will:

1. Decrease geometric (or radiation) damping
2. Increase the resonant frequency f_r and may also increase f_n
3. Influence the amplitude near resonance
4. When laterally loaded, produce dynamic responses that are uncertain to estimate

The principal effort in dynamic pile analyses has been undertaken by and under the direction of the late Professor M. Novak at the University of Western Ontario, Canada. The basic theory is given by Novak (1974) and Novak and Howell (1977) for torsion. The dynamic pile equations of Novak (1974) are of the following general form using Novak's notation and noting $i = \sqrt{-1}$:

Horizontal and rocking: $$G'(S_{u,1} + iS_{u,2})u(z, t)dz = F(t)$$

Vertical: $$G'(S_{w,1} + iS_{w,2})w(z, t)dz = F(t)$$

The parameters $S_{i,j}$ depend on Poissons' ratio μ and $x_o = a_o\sqrt{q} = \left(r_o\omega\sqrt{q}\right)/V_s$. Terms are defined in the following list if not identified here. The term q is given as

$$q = \frac{1 - 2\mu}{2 - 2\mu}$$

From using $i = \sqrt{-1}$ we can see the $S_{u,j}$ factors are complex and in the original derivation include Hankel functions of the second kind of orders 0, 1, and 2 based on a_o and x_o.

The $S_{w,j}$ factors are also complex and include Bessel functions of order 0 and 1 based on a_o and x_o. It is convenient to program the Bessel and Hankel function computations as subroutines to obtain the $S_{i,j}$ functions without having to use charts, tables, or curve-fitting schemes. This step is done in computer program B-30.

The following list of variables are also significant problem parameters:

E_p = modulus of elasticity of pile
G' = shear modulus of soil (and depends on μ)
γ_p, γ_s = unit weights of pile material and soil, respectively
V_p, V_s = shear wave velocities in pile and soil respectively [for the pile compute $V_p = \sqrt{E_p/\rho}$; for the soil use Eq. (20-15)]
L_p/r_o = ratio of pile length L_p/effective radius of pile r_o
r_o = effective radius of pile = radius of round pile and the equivalent for a square or rectangular pile computed as $r_o = \sqrt{\text{area}/\pi}$

a_o = dimensionless frequency factor previously used but here defined as $a_o = \omega r_o \sqrt{q/V_s}$; q = Poisson ratio value previously defined; ω is same as used in Eq. (20-4)

One must use consistent units, and with a_o as a problem parameter it is evident the pile springs and damping constants will be frequency-dependent since a_o is used to obtain the $S_{i,j}$ factors.

The general solution is only practical by using a computer program to develop the necessary constants for use in the stiffness and damping constants. Novak (1974) provides a number of curves and a table of some values, but invariably a practical problem requires interpolation or falls out of the table range. The references give the necessary information so that one can produce a computer program, but it will have to be written in a computer programming language, which allows manipulation of complex variables.

Solutions are provided for all six degrees of freedom of the base with proper interpretation and for piles with the head fixed in the base and the lower end either pinned or fixed. It appears that for the pile lengths (in terms of the L_p/r_o ratio) likely to be used the fixed lower end case will occur for nearly all cases. The theoretical solutions for the fixed lower end and the pinned lower end converge at about $L_p/r_o = 25$ to 30. The solution produces factors $f_{i,i}$ that are multipliers to obtain the actual spring and damping constants. Generally these $f_{i,i}$ constants depend on the following:

Parameter	Amount of dependency
V_s/V_p	Considerable as illustrated in Table 20-6
L_p/r_o	Not much for $L_p/r_o > 25$
μ	Not much, e.g., for $V_s/V_p = 0.030$ and $L_p/r_o > 25$,

μ	$f_{18,1}$	$f_{7,1}$
0.25	0.0373	0.339
0.33	0.0373	0.345
0.40	0.0373	0.351

a_o	Substantial—particularly above 0.50

Table 20-7 lists the spring and damping constants computed using the $f_{i,i}$ constants given in Table 20-6 for a typical concrete pile.

When the spring and damping constants are computed for a single pile it is necessary somehow to concentrate the several piles to an equivalent total or global spring and damping coefficient that, together with the block mass m, are used in Eq. (20-4*a*) to compute displacement amplitudes and other data. There are conflicting opinions on how to make the summing process. Most persons agree that if the pile spacing ratio s/D is greater than 5 or 6 one can make a summation by simply adding the individual pile contributions (where the piles are all similar and there are n piles the global spring $= n \times K_{\text{pile}}$ and global damping $= n \times c_{\text{pile}}$). When the s/D ratio is less, there is opinion that corner piles contribute more than side piles and side piles contribute more than interior piles. A method suggested by Poulos (1979) has been noted by Novak (1974) and suggested by Arya et al. (1979). Others having used the Poulos (1979) method have found it does not predict

TABLE 20-6
Novak's $f_{i,j}$ values for an intermediate value of $\mu = 0.33$ for a concrete pile with $\rho_s/\rho_p = 0.7$

Values from author's computer program based on Novak (1974) and Novak and Howell (1977). Values $f_{12,i}$ are for torsion and use author's identification.
Fixed parameters: $L/r_o = 30$, $a_o = 0.3$ and for torsion $\beta = 0.10$, $\mu = 0.33$.

	Stiffness					Damping				
V_s/V_c	$f_{18,1}$	$f_{7,1}$	$f_{9,1}$	$f_{11,1}$	$f_{12,1}$	$f_{18,2}$	$f_{7,2}$	$f_{9,2}$	$f_{11,2}$	$f_{12,2}$
0.01	0.034	0.199	−0.019	0.004	0.045	0.002	0.136	−0.028	0.008	0.002
0.02	0.035	0.282	−0.038	0.010	0.072	0.007	0.198	−0.056	0.023	0.007
0.03	0.037	0.345	−0.057	0.018	0.105	0.016	0.245	−0.084	0.043	0.011
0.04	0.040	0.398	−0.076	0.027	0.139	0.027	0.283	−0.112	0.066	0.015
0.05	0.044	0.445	−0.095	0.038	0.174	0.041	0.314	−0.141	0.092	0.019
0.06	0.049	0.448	−0.114	0.050	0.208	0.055	0.346	−0.169	0.122	0.022

displacement amplitudes very well. The method does, however, consider interior piles to contribute less resistance than exterior and corner piles. Since the Poulos method does not predict very well and it is fairly computationally intensive, the author suggests either doing nothing but sum values or considering the following approach if *s/D* is less than about 3.5:

1. When displacement piles are driven the soil densifies in the vicinity of the pile. The densification is more concentrated at the interior of a pile group than around the exterior piles. This suggests that we should use a base factor G' for the soil (prior to the pile insertion

TABLE 20-7
Pile spring and damping constants [Novak (1974), Novak and Howell (1977)]

Mode	Spring K_1	Damping c_1
Vertical	$K_z = \frac{EA}{r_o} f_{18,1}$	$c_z = \frac{EA}{V_s} f_{18,2}$
Horizontal	$K_h = \frac{EI}{r_o^3} f_{11,1}$	$c_h = \frac{EI}{r_o^2 V_s} f_{11,2}$
Rocking	$K_\theta = \frac{EI}{r_o} f_{7,1}$	$c_\theta = \frac{EI}{V_s} f_{7,2}$
Cross-stiffness/damping	$K_{x\theta} = \frac{EI}{r_o^2} f_{9,1}$	$c_{x\theta} = \frac{EI}{r_o V_s} f_{9,2}$
	$K_{\theta x} = K_{x\theta}$	$c_{\theta x} = c_{x\theta}$
Torsion	$K_t = \frac{G'J}{r_o} f_{12,1}$	$c_t = \frac{G'J}{V_s} f_{12,2}$

Use consistent units for all
where E = modulus of elasticity of pile
A = cross-section as area of pile
G' = shear modulus of pile
I = moment of inertia of pile about axis to resist displacement
J = torsion (or polar) moment of inertia of pile