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Designing the Concrete-Framework Building and Examining its Behavior under the Explosion Load

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***Abstract*—**These Nowadays the explosion of bombs or explosive materials such as gas and oil near or inside the buildings cause some losses in installations and building components. This has made the engineers to make the buildings and their components resistance against the effects of explosion. These activities lead to provide regulations and different methods. The above regulations are mostly focused on the explosion effects resulting from the vehicles around the buildings. Therefore, the explosion resulting from the vehicles outside the buildings will be studied in this research.

In the present study, the main goals are to investigate the explosion load effects on the structures located on the piles with the specific quantity of plasticity and observing the permissible response of these structures. The concentrated mass system and the spring with two degree of freedom will be used to study the structural system.

***Keywords*—**Concrete-Framework Building, Explosion Load, piles.

I. Introduction

IN most of the previous researches about the explosion effects, the foundation system of the structure has not been considered because of this reason that most of the engineers with an utmost design exercise the effects of explosion to the foundation. This absence of investigation increases the price of the structure design for an employer. Therefore in this research, the foundation system will be also analyzed dynamically for the explosion load.

The dynamic analysis of foundation system consists of calculating the peripheral leap of system under the dynamic load effect. For this purpose, in the present research we have used computer programs written in FORTRAN language. The first program is GS.FOR which is used for calculating the hardness of pile group. This program is on the basis of Nowak and Sharnobay methods. The second one is SPPLN.FOR. This program is for calculating the peripheral leap of the single pile under the subsidiary load effect. In the above program, the floating pile in the soil is modeled as a beam on the elastic bed (Winkler method) and will be analyzed based upon the restricted element method.

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The explosion load exercises to the structure immediately, with high intensity and in a short period. The elastic design for this kind of loading if possible is too expensive to perform. But regarding the elastic-plastic behavior, the resistant power of the components will be stored and cause the structure to present the plastic behavior. When the structure shows its elastic-plastic behavior, it can consume lots of energy, and this is the very region in which we are interested in designing all kinds of intense and tacit loads. Therefore, we can decrease lots of designing load when the structure is permitted to inter into the plastic procedure (with plasticity restriction). The present discussion is on this basis that we permit the structure to encounter a series of small breakdowns. Regarding the elastic-plastic behavior, in addition to the economic designing, the structure will remain usable after a relatively harsh hit [1],[2]. A lot of studies have been done about the explosion and its effects [3]-[7].

In the present study, the main goals are to investigate the explosion load effects on the structures located on the piles with the specific quantity of plasticity and observing the permissible response of these structures. The concentrated mass system and the spring with two degree of freedom will be used to study the structural system.

II. Design properties

The considered building in this study is a concrete-framework one-floor building under the explosion load which analyzes this structure and the effects of different structural parameters will be investigated on it. According to the fig.1 , the structure and the foundation system properties are as follows:

The frame height is 3.6 m, the frame length is 6 m, the frame span is 6 m, the opposite face of the explosion is 6×3.6 m^2 as well as concrete with 20^{mpa} resistance and steel with 415 mpa resistance. The length of pile is L_f: 15m and the pile diameter is D_f: 0.45m.The sand cushion and the horizontal elasticity modulus is K_h=5000 kN/m^3.

The other foundation properties:

The peripheral freight capacity peak of each pile is 30 KN, the safety factor of each pile is 2.5, the soil shear modulus is G= 15N/mm^2, the Poisson factor is v= 0.2 and the elastic modulus is E_{dyn}= 30000 N/mm^2.

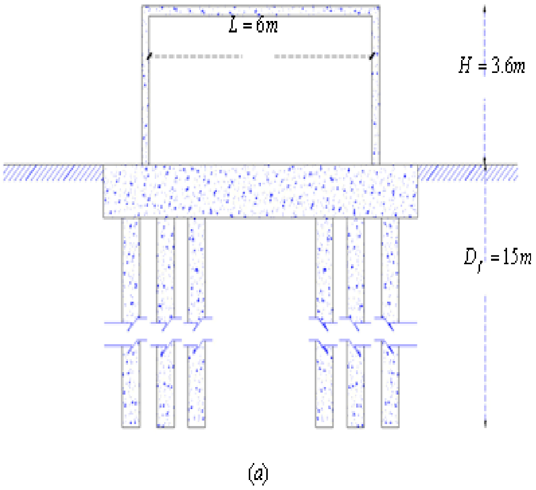

Fig.1 the building frame located on the pile

III. The Effect of Explosion Load on the Concrete Properties

The mechanical properties of the reinforced concrete under the dynamic loads are completely different from the static ones. These differences will be manifested while system is placed under the dynamic loading in a specific period of time. Since the dynamic and static hardness of a system are not very different from each other, but with increasing the strain rate of the concrete, the compression strength increases up to quadruple and the tensile strength increases up to sextuple. Increasing the mentioned resistance is under the strain rate of (10^2 up to 10^3). This high strain rate (loading) will affect its components. The structures of the reinforced concrete also affect the concrete and reinforcement properties which will be mentioned below individually.

The explosion load on the structure will be investigated with the following three ideal conditions:

- ✓ The rigid foundation and the elastic-plastic superstructure
- ✓ The rigid superstructure and the elastic-plastic foundation
- ✓ The elastic-plastic superstructure and foundation

This structure will be designed and analyzed in the system with two degree of freedom. It is presumed that T= 0.25 sec and T is the natural period of the structure. The proportion of explosion time to the structure period is equal to $\tau = 0.12$ and the high pressure resulting from the explosion corresponds to 70 kN/m^2.

IV. The Effect of the Type of Elastic-Plastic Diagram on the Structure Response

The concepts use for structure design against the explosion are different from the concepts use in the usual building design. These differences are because of the loads resulting from the explosion which basically are different from the usual loading. The very restricted repetition of this kind of loading once or twice permits the designer to take the advantage of structure energy absorption.

In order to use this property, the structure has a permission to deform more than its elastic form otherwise the structure system exits the economic mode of system. So, using the plasticity of components and materials is necessary. For this reason the over deformation of yield is essential for the economic design of the structure. The maximum proportion of the elastic-plastic leap to the yield point one is called “the proportion or the plasticity coefficient”. In equal circumstances for the structures, the more the plasticity rate is, the less the required resistance power will be. So, the plasticity effect should be investigated in the structure well. In this research, we have studied the effect of utilized elastic-plastic diagram on the structure response. As we know, the utilized diagram in an ideal model is a two-line diagram whose behavior is different from the real behavior of the structure. For this reason, the elastic-plastic two-line diagram in analyzing the ideal model will be substituted with a three-line diagram.

V. Result

GS.FOR program was used to calculate the hardness of pile group, and SSPLL.FOR was used to calculate the hardness of single pile. The results are as follows:

The response of the foundation with one and two degree of freedom and the comparison of system foundation response with two degree of freedom with that of one degree freedom have been shown in table number 1 as well as the comparison of the system frame (superstructure) response with two degree of freedom with that of one degree of freedom which has been shown in table number 2.

TABLE I
COMPARING SYSTEM FOUNDATION RESPONSE WITH TWO DEGREE OF FREEDOM WITH THAT OF ONE DEGREE OF FREEDOM

Row	foundation resistance	one degree			two degree			Plasticity variance	System's parameters	
	(KN)	$X_e(mm)$	$X_m(mm)$	$\mu=\frac{X_m}{X_e}$	$X_e(mm)$	$X_m(mm)$	$\mu=\frac{X_m}{X_e}$		one degree	two degree
1	500	10.202	38.295	3.754	10.202	26.56	2.603	44.22		$P_{bc}=1925kN$
2	450	9.187	41.47	4.514	9.187	29.54	3.215	40.40		$P_{bf}=1925kN$
3	400	8.166	45.58	5.582	8.166	33.91	4.154	34.44	$m_f=98000kg$	$m_c=30896kg$ $m_f=57300kg$
4	350	7.145	51.01	7.14	7.145	41.11	5.754	24.10	$K_f=48980kN/m$	$K_c=24090.6kN/m$
5	300	6.125	58.43	9.54	6.125	52.73	8.61	10.80	$P_{bf}=3850kN$	$K_f=48980kN/m$
										$R_{mc}=165kN$ $R_{mf}=450kN$

TABLE II
COMPARING SYSTEM FRAME (SUPERSTRUCTURE) RESPONSE WITH TWO DEGREE OF FREEDOM WITH THAT OF ONE DEGREE OF FREEDOM

Row	Frame resistance (KN)	one degree			two degree			Plasticity variance	System's parameters	
		$X_e(mm)$	$X_m(mm)$	$\mu=\frac{X_m}{X_e}$	$X_e(mm)$	$X_m(mm)$	$\mu=\frac{X_m}{X_e}$		one degree	two degree
1	180	7.47	81.71	10.97	7.47	57.47	7.73	41.91	$m_f=98000kg$ $K_f=48980kN/m$ $P_{of}=3850kN$	$R_{s}=1925kN$ $R_{sf}=1925kN$ $m_c=30896kg$ $m_f=57300kg$ $K_c=240906kN/m$ $K_f=48980kN/m$ $R_{mc}=165kN$ $R_{mf}=450kN$
2	165	6.85	89.57	13.1	6.85	68.33	9.98	31.26		
3	150	6.23	98.0	15.73	6.23	80.0	12.84	22.50		
4	125	5.188	116.75	22.5	5.188	99.19	19.12	17.67		
5	100	4.151	139.86	33.69	4.151	120.33	29.0	16.17		

In order to investigate the effect of the utilized elastic-plastic diagram on analyzing the structure response, the ideal model was analyzed for two diagrams and the results were examined. For a comprehensive investigation, we analyze the analytic model for different (P_0/R_M) (P_0 is the exercised peripheral power to the model and R_M is model resistance) in different (T_D/T) (T_D is the explosion time and T is the structure period), then we compare the plasticity coefficient and finally, we present the results of three-line elastic-plastic diagram comparison with an ideal (two-line) diagram on the structure response in TABLE III.

TABLE II
COMPARING THE RESULTS OF THE THREE-LINE ELASTIC-PLASTIC DIAGRAM WITH AN IDEAL (TWO-LINE) DIAGRAM ON THE STRUCTURE RESPONSE

P_o/R_m	t_d/T	Plasticity factor of two-line system	three-line system	amount of difference %
2	0.2	1.2215	1.1566	5.313
	0.3	1.9602	1.8921	3.58
	0.4	2.8424	2.7562	3.0326
	0.6	5.01	4.8908	2.379
	0.8	7.70	7.56	1.86
	0.9	9.24	9.08	1.69
	1.0	10.92	10.75	1.50
3	0.2	2.12	2.06	2.74
	0.4	6.095	5.997	1.60
	0.5	8.82	8.71	1.31
	0.6	12.07	11.92	1.21
	0.9	24.72	24.50	0.87
5	0.1	1.7022	1.6831	1.12
	0.2	5.03	4.97	1.28
	0.3	10.2	10.1	1.1
	0.4	17.2	17.06	0.78
	0.5	21.37	21.21	0.71
10	0.05	1.7234	1.7162	0.42
	0.1	5.304	5.26	0.62
	0.15	11.09	11.03	0.58
	0.20	19.02	18.96	0.35

VI. CONCLUSION

In this study which was presented as "designing the concrete-framework building and examining its behavior under the explosion load", it was determined that the great changes appear in the frame (superstructure) leap of the systems with one and two degree of freedom. Therefore, in more precise methods, a system with two degree of freedom presents more economic results. With decreasing the hardness of the system, the amount of plasticity changes decrease in the systems with one and two degree of freedom. Also, the leap and the plasticity of two components of system (frame and foundation) are sensitive to the system resistance. Frame plasticity is almost compatible with the system resistance but as it was mentioned, the foundation rarely shows this sensitivity. Here is an important point: if the resistance of one of the system components (superstructure or foundation) changes, the changes patterns in the plasticity of both systems will be opposed to each other. With increasing the foundation resistance, the frame plasticity increases meaningfully, but with increasing the frame resistance, the foundation plasticity increases with lower speed so that it shows about 20% increase in plasticity instead of 100% increase in the foundation resistance.

In order to reforming the elastic-plastic diagram and making closer the ideal model behavior to the structure real ones, the three-line diagram instead of the two-line ones has been used in the analysis, but as it was presented in the results, the amount of difference is between 0/5% to 5%. This small error witnesses that the type of utilized diagram in the analysis, has a small effect on the structure response.

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