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A DESIGN OF STRUCTURE TO RESIST A BLAST FROM CONVENTIONAL WEAPON

KEYWORDS: Crash loads, Conventional firearmstar, Crash wave phenomenon, Crash resistance and Eruptive devices.

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ABSTRACT The increase in number of terrorist attacks and synthetic disasters especially in last few decades, shows that there is an increase in effect of crash loads on building so this effect should be taken in consideration in design process. Crash loads are similar to dynamic loads, and there is a need to be calculated carefully just likes wind loads and earthquake. Firstly eruptives and detonation sorts have been explained briefly. In addition effects of eruptives on buildings have been presented. A better understanding of eruptives and characteristics of detonations makes a design of crash resistance building more effective. A better understanding of Crash wave phenomenon makes crash resisting design more efficient, places a predominant role in design consideration. Different sorts of eruptives gives different detonations, in this paper eruptive is taken as conventional firearmstar, and the building is above ground. The Indian code does not have enough provinces for crash load, so it is important to study crash loading as a dynamic loading. Among the various techniques sandwich structures are considered in design, since it has to resist high thwack loads.

INTRODUCTION

One of the basic needs of all living creatures is to have safe and secure shelter. There is a need to develop capabilities to protect themselves against both natural disasters and hazards associated with synthetic activities. Furthermore there is a increasing need to protect civilian occupants against terrorism. Any successful response will require a well planned multi-layered approach that strikes a fine balance between nation's security and maintaining freedoms that modern society enjoys.

1.1 Security categories

The security afford by a facility pr its components can be subdivided into four security categories as described below:

1. Security Category 1 - Protect personnel against the uncontrolled release of hazardous materials, including toxic chemicals, active radiological or biological materials; attenuate crash thrusts and structural motion to a level consistent with personnel tolerances; and shield personnel from primary and secondary fragments and falling portions of the structure and/or apparatus.

2. Security Category 2 - Security apparatus, supplies and stored eruptives from fragment thwack, crash thrust and structural response.

3. Security Category 3- Thwart communication of detonation by fragments, high-crash thrusts, and structural response.

4. Security Category 4- Thwart mass detonation of eruptives as a result of subsequent detonations produced by communication of detonation between two adjoining areas and/or structures.

1.2 Security methodology

A rational approach for selecting appropriate protective measures for an asset is based on comparing the cost of mitigation with the cost of the consequence if no improvements are made in protecting an asset. Initially, small investments in protecting an asset can provide significant benefits. However, additional security enhancements will become increasingly more expensive.

Understanding and defining possible threats or hazards is essential. Such information is the first step for developing credible loading definitions that must be available to ensure the selection of acceptable mitigation approaches. Furthermore, threat assessments must be performed sessionically to evaluate the suitability of existing mitigation measures based on previous threat assessments.

ERUPTIVE DEVICES AND DETONATIONS

The comprehensive risk management approach may indicate that a threat to be addressed involves the use of eruptive devices. Therefore one must understand eruptive effects and process that generate them. The designer or analyst must have reasonable assessments on the sort of firearmstar arrangements that could be applied to the structure under consideration.

- **Conventional firearmstars**

Addressing military ordnance is important not only for design of military- sort protective structures, but also because many improvised eruptive devices (IEDs) are produced with either stolen or discarded firearmstars. Typical military devices are introduced first, and detonation processes and phenomena are treated, as the foundation for defining physical threat environments. There various sorts of conventional firearmstars are there like small arms, aircraft canon rare trajectiles, High Eruptive bombs (HE bombs). Among the various HE firearmstars, in this paper we considered 1000lb General Purpose firearmstar. Some specifications are given in table-1, whereas typical layout is given in fig-1

Table – 1: GP BOMB SPECIFICATIONS

BOMB	1000-lb
Construction	Cast steel
Usual weight	1072-lb
Body length	52.5 in
Tail length	35.5 in
Body diameter	16.15in (41.02cm)
Wall thickness	0.77in (1.95cm)
Tail width	16in (40.64cm)
Filling	Amatol 60/40 or RDX/TNT 60/40
Charge/weight ratio	33%

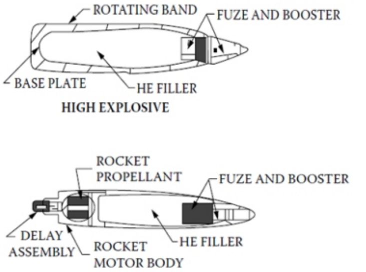

Figure 1: High eruptive
Source : unified facility criteria 3-340-2

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CRASH WAVE PHENOMENON

The environment created by an detonation involves several effects, like air crash, ground shock, ejecta, fragments, fire thermal and chemical. An detonation generates a shock wave that has a thrust that decays with stretch. Conventional high eruptives tend to produce different magnitudes of peak thrust, heat production etc. As a result, the environments they produce will be different from each other. In order to establish a base for comparison, various eruptives are compared to equivalent TNT values. Since the values for such comparisons are different at different thrust levels, and since the comparison can be for either thrust or impulse, average equivalency influences must be used for TNT equivalent weight and thrust is 1 as a standard. Another approach to compare the effects of different eruptives is based on their heat of reaction.

An important issue in the analysis and design of protective structures is comparison of effects from firearmstars denoted at different stretchs. Such a comparison can be made by employing acceptable scaling laws. One approach is cube root scaling used to relate eruptive effects on the basis of corresponding energy levels.

EXTERNAL DETONATION

The general shape of a air crash shock wave thrust-moment history for an open air detonation is illustrated in fig-2 the shock front is essentially vertical reflecting the sudden rise in thrust due to detonation. The peak incident thrust P_{so} is at the end of initial phase (rise moment). The incident thrust is the thrust on a facet parallel to the direction of propagation. The propagation velocity decreases with moment, but it is typically greater than the speed of sound in medium.

Gas fragments moves at velocity u. the fragment is associated with the dynamic thrust, which is caused by wind generated from the crash shock fronts. Since the shape of shock wave depends on the energy released in to the volume that is defined by front location, as the shock front propagates away from the detonation center, the peak incident thrust can be decreases and the duration decreases.

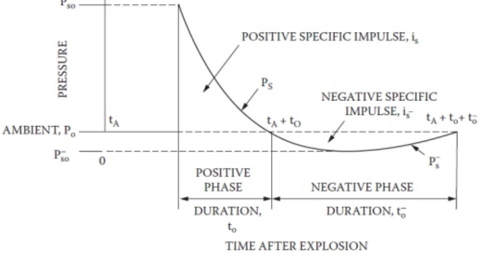

Figure 2: Free field thrust - moment variation
Source : Unified facility criteria 3-340-2

The shock front arrives at the target at the moment t_a and attaines the peak incident thrust P_{so} at t_r (rise moment) after t_a

Since the rise moment is very short, an instantaneous rise to peak thrust can be assumed .the peak thrust decays to the ambient value in moment t_o and this is defined as the positive phase of thrust pulse. Following is the negative phase for duration of t^-_o, characterized by thrust v lower than the ambient thrust and a reversal of wind (fragment flow).

If the shock waves attaines a facet that is not parallel to the direction of propagation (such as a wall or a structure), a reflected thrust is generated as shown in fig-3. The reflected thrust has the same general shape of incident thrust, but peak is higher than that of incident wave as shown in fig -3.the reflected thrust depends on the incident wave and on the angle of inclined facet. this flow from high thrust to the lower thrust regions reduces the reflected thrust to the stagnation thrust.

CRASH ENVIRONMENT

The problem is more complicated when an detonation occurs a short stretch from the target. The spherical shock wave that propagates away from the center of detonation is also reflected from the ground before attaining the target. The reflection from the ground interacts with original shock wave to produce a resultant shock front known as Mach Front.

The point at which the initial wave, the reflected wave and the mach front meet is the triple point. Triple point defines the height of front, to simplify the problem. The thrust distribution must be adjusted accordingly (a uniform thrust up to triple point and incident thrust above it).

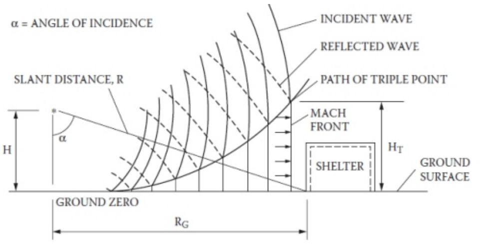

Figure 3: Crash environment from air burst
Source: Unified facility criteria 3-340-2

When an detonation occurs at ground facet, simultaneous reflections from ground are obtained. The parameters for the facet detonation are obtained from the relationships, as the air burst, the parameters are calculated for the assumption of planar wave(i.e., structure is assumed to be far from the detonation).

The dynamic thrust must be derived also, since it represents the effects of wind from detonation. The peak dynamic thrust q_o is related to the peak incident thrust P_{so}. The duration of approximate positive phase t_{of} is computed by equation

$$2i_s/P_{so}=t_{of}$$

PUNCTURING

A protected structure must be designed to thwart the detonation effect from hurting people and/or adversely affecting the mission of facility. On the other hand firearmstar is designed to attain as close as possible to the site that will be damaged by the detonation, therefore, the detonation may occur at the firearmstars maximum puncturing depth. The protective arrangement must reduce the depth of puncturing in order to maintain a safe standoff stretch from center of detonation. The puncturing process is characterized by three typical phases.

1) Thwack
2) Travel through protective materials
3) Post puncturing condition

The thwack may cause damage due to crushing or yielding of materials at the point of contact and scabbing at back side. The scabbing is produced by reflection of stress waves at rear face. An detonation at front face may cause similar effects. It was shown by tests that scabbing becomes a problem for concrete when a 50% puncturing of protective layer thickness is achieved, for 63% or more puncturing, one may expect full perforation.

AIR CRASH AFFECTED GROUND SHOCK

When an detonation occurs at or near the ground facet, ground shocks results from the energy imparted to the ground by detonation. Some of this energy is transmitted through the ground as direct-affected ground shock. Air-Affected ground shock results when the air crash shock wave compresses the ground facet and sends a stress pulse into underlying media. The magnitude and duration of stress pulse in the ground depend on the character of the air-crash pulse and the ground media. Generally, the air- affected ground motions are downwards. They are maximum at ground facet

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and attenuate with depth.

In stiff soils, pulses are shorter, are at higher frequencies and acceleration, and have lower displacements than in softer (looser) soils. The relationship between peak fragment velocity and peak thrust is based on the wave propagation as follows

$$P_0 = V_{0\rho} c$$

Here P_0 peak soil stress,
ρ soil mass density,
c seismic velocity derived based on 1D wave propagation

Dynamic increase influence

Depending upon the magnitudes of the crash output and permissible deformations, one of three sorts of reinforced concrete cross sections (Table 5.4) can be utilized in the design or analysis of crash resistant concrete slabs:

1) Sort I - The concrete is effective in resisting moment. The concrete cover over the reinforcement on both facets of the element remains intact.

2) Sort II - The concrete is crushed and not effective in resisting moment. Compression reinforcement equal to the tension reinforcement is required to resist moment. The concrete cover over the reinforcement on both facets of the element remains intact.

3) Sort III - The concrete cover over the reinforcement on both facets of the element is completely disengaged. Equal tension and compression reinforcement which is properly tied together is required to resist moment. Elements designed using the full cross section (Sort I) are usually encountered in those structures or portions of structures designed to resist the crash output at the far design range. This sort of cross section is utilized in elements with maximum declinations corresponding to support rotations less than 2 degrees. Maximum strength of an element is obtained from a Sort I cross section. Sort I elements may be reinforced on either one or both faces.

Table -2
Dynamic increasing influences for design of RCC elements

Sort of stress	Far design range			Close-in design range		
	Reinforcing bars		concrete	Reinforcing bars		concrete
	f_{dy}/f_Y	f_{du}/f_u	f_{dc}/f'_c	f_{dy}/f_Y	f_{du}/f_u	f_{dc}/f'_c
Bending	1.17	1.05	1.19	1.23	1.05	1.25
Diagonal tension	1.00	---	1.00	1.10	1.00	1.00
Direct shear	1.10	1.00	1.10	1.10	1.00	1.10
Bond	1.17	1.05	1.00	1.23	1.05	1.00

Source: unified facilities criteria 3-340-2

LOAD-MASS INFUENCE

The load-mass influence is a influence formed by combining the two basic transformation influences, K_L and K_M. It is merely the ratio of the mass influence to the load influence, and it is convenient since the equation of motion may be written in terms of that influence alone.
The equation of motion of the actual arrangement is given as

$$F - R = Ma$$

and for the equivalent arrangement

$$K_L F - K_L R = K_M Ma$$

HERE K_L=load influence
$K_{M=}$= mass influence

NATURAL SESSION OF VIBRATION OF SLAB

The effective natural session of vibration is

$$Tn = 2\pi\sqrt{(m/KE)} = 2\pi\sqrt{(KLMm/KE)}$$

where

m= the effective unit mass or total mass above slab
KE = the equivalent unit harshness of arrangement

DESIGN FOR REBOUND

The beam must be designed to resist the negative declination or rebound which occurs after the maximum positive declination has been attained. The negative resistance r-, attained by the beam when subjected to a triangular pressure-time load

ULTIMATE MOMENT

$$M(u) = A(s) * f(dy)\, d - a/2$$

Here $a = A(s) * f(dy) / 0.85 * b * f'(dc)$

UNREINFORCED WEB SHEAR CAPACITY

The shear stress permitted on an unreinforced web of a beam subjected to flexure only is limited to:

$$VC = 1.9 * \sqrt{f'dc} + 2500p \leq 3.5 * \sqrt{f'dc}$$

Where
V_c = maximum shear capacity of an unreinforced web
p = reinforcement ratio of the tension reinforcement at the support

ULTIMATE SHEAR STRESS

The nominal shear stress *vu*, as a measure of diagonal tension, is computed from:

$$v_u = V_u / bd$$

where:
v_u = nominal shear stress
Vu = total shear at critical section

The critical section is taken at a distance, *d*, from the face of the support for those members that cause compression in their supports.

The shear at sections between the of the support and a distance, *d*, from the support therefore need not be considered critical. For those members that cause tension in their supports, the critical section is at the face of the supports

.V_u =total shear at a critical section

$$= \left(\frac{L}{2} - \frac{X}{2} - d\right) r(u)$$

Here X is the is width of support along the span of slab.

DESIGN OF SHEAR REINFORCEMENT:

Closed ties placed perpendicular to the flexural reinforcement must be used to outfit the additional shear capacity. Open stirrups, either single or double leg, are not permitted. The required area of shear reinforcement is calculated using.

$$A = \frac{(Vu - Vc)bs}{0.85 * f'ds}$$

$(Vu - Vc) = 27psi$ of excess shear.

Ss = spacing of stirrups in direction parallel to longitudinal reinforcement.

- **Minimum Shear Reinforcement:**

In order to insure the full development of the flexural reinforcement in a beam, a premature shear failure must be prevented. The following limitations must be

considered in the design of closed ties:
1. The design shear stress (excess shear stress $\nu_u - \nu_c$) shall be equal to or greater than the shear capacity of unreinforced
2. The nominal shear stress ν_u must not exceed 10 ($f'dc$)1/2.
3. The area *Av* of closed ties should not be less than 0.0015 bss.
4. The required area *Av* of closed ties shall be determined at the critical section and this quantity and spacing of reinforcement shall

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be used throughout the entire member.
5. The maximum spacing of closed ties is limited to $d/2$ when $v_u - v_c$ is less than 4 ($f'dc$)1/2 or 24 inches, whichever is smaller. When $v_u - v_c$ is greater than 4 ($f'dc$)1/2 the maximum spacing is limited to $d/4$.

Therefore v(min) = 0.85V_c

MOMENT CAPACITY OF SLAB

- **Ultimate moment:**

The ultimate unit resisting moment *Mu* of a rectangular section of width *b* with tension reinforcement only is given by

M(U) =A(s)* f(dy)*(d-a/2)

where:
As = area of tension reinforcement within the width b
fdc = dynamic design stress for reinforcement
d = distance from extreme compression fiber to centroid of tension reinforcement
a = depth of equivalent rectangular stress block
b = width of compression face
f'dc = dynamic ultimate compressive strength of concrete
HERE a=A(s) * f (dy) / 0.85*b*f'(dc)

CONCLUSIONS

Numerical simulation is a useful tool for estimation of damage caused by crash and fragment thwacks. This is mainly due to the low costs, ease of carrying out parameter studies, and the possibility to better follow and understand the principal phenomenon involved, compared to fact finding testing. However, since the material models used in the simulation, and their ability to describe the real behavior, are crucial for the simulation results, their limitations must be known by the user and taken into account when analyzing. By considering all these influences, here we have considered GP1000 firearmstar which falls directly on slab of a structure, in order to decrease the depth of puncturing we have considered sandwich sort slab, which means top and bottom consists of protective slab of depth 1500mm and middle as 900 mm thickness of dry soil slab which may result in reduction of sapling crater, and scabbing. The reinforcement in a concrete structure is necessary in order to ensure ductile behavior and thereby an energy-absorbing capacity, but may also increase the resistance against local damage. However, an increased rare trajectile resistance, i.e. decreased depth of puncturing, can only be achieved with, for this case, suitable reinforcement detailing, since the reinforcement must be present in the damage zone in order to have an effect. Furthermore, the stretch between the rare trajectile path and the reinforcement bars is a crucial influence since the confinement effect of the reinforcement, pointed out as a reasonable explanation for the increased rare trajectile resistance, puncturing of firearmstar decreases with increasing stretch. Reinforcement bars almost always reduce the scabbing and spalling effects.By using the above conclusions, we have made an analysis on Crash loads by using numerical simulation and design of slab.

REFERENCES:

[1]. TM 5-1300(UFC 3-340-02) U.S. Army Corps of Engineers (1990), "Structures to Resist the Effects of Accidental Detonations", U.S. Army Corps of Engineers, Washington, D.C., (also Navy NAVFAC P200-397 or Air Force AFR 88-22).
[2]. Schmidt, Jon A. (2003), "Structural Design for External Terrorist Bomb Attacks", STRUCTURER magazine, March issue.
[3]. A. Khadid et al. (2007), " Crash loaded stiffened plates" Journal of Engineering and Applied Sciences,Vol. 2(2) pp. 456-461.
[4]. IS 456:2000 Indian Standard Plain and Reinforced Concrete Code of Practice.
[5]. T. Borvik et al.(2009) "Response of structures to planar crash loads – A finite element engineering approach" Computers and Structures 87, pp 507–520
[6]. American Society for Civil Engineers 7-02 (1997), "Combination of Loads",pp 239-244.