A COMPARISON BETWEEN BLAST DEBRIS FROM LIGHTWEIGHT AND NORMAL CONCRETE STRUCTURE

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ABSTRACT

This is a research on Blast Debris Field Study - Comparison of Blast Debris from Lightweight and Normal Concrete with the focus on throw distance, shape and size of concrete fragments. This report presents the review on available literature references on the subject that contribute to the understanding on the selected material, blast loading and blast debris. The testing requirements and method adopted are outlaid with the debris collection technique and data sheets. Selection of the scaled test model, design and specifications, construction material and computations of suitable blast loading for the test are presented. Scaled models from lightweight and normal concrete are casted and blasted using adequate explosive charge. A full report on the execution of the blast test and analysis of the result are presented. Blast debris analysis was conducted and the result proved that debris from lighter density concrete produce shorter throw distance. Density of concrete does not influence the shape and size of debris. Lightweight concrete possess the properties that can reduce the safety distance and reduce risk to human and property.

ABSTRAK

Ini adalah kajian tentang taburan serpihan letupan – perbandingan di antara serpihan letupan daripada struktur yang diperbuat daripada bahan konkrit ringan dan konkrit biasa. Penumpuan adalah ke atas jarak balingan, bentuk dan saiz serpihan letupan. Laporan ini membentangkan hasil pembacaan ke atas beberapa sumber rujukan mengenai pemilihan bahan binaan, beban letupan, dan serpihan letupan. Keperluan dan tatacara ujian beserta teknik pengutipan serpihan dan boring-borang data dikemukakan. Pemilihan model ujian berskala, rekabentuk dan spesifikasi, bahan binaan, dan pengiraan beban letupan juga dikemukakan. Modal berskala daripada konkrit ringan dan konkrit biasa dibina dan diletupkan dengan kuantiti bahan letupan yang mencukupi. Laporan perlaksanaan ujian dan analisa letupan turut dikemukakan. Analisa serpihan letupan telah membuktikan bahawa konkrit berketumpatan yang lebih rendah menghasilkan jarak balingan serpihan letupan yang lebih dekat. Ketumpatan konkrit tidak mempengaruhi bentuk dan saiz serpihan. Konkrit ringan mempunyai ciri-ciri yang dapat mengurangkan jarak keselamatan dan mengurangkan risiko kepada manusia dan harta benda.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Strength is not the only criteria when selecting material for the construction of blast related structures on facilities. When an explosion occurs, it is accompanied by blast overpressure, shock, thermal radiation, projectiles of primary and secondary fragment. The building material normally becomes the secondary fragment as projectiles that travel with high speed and high impact load. These fragments in most cases causes more fatal injuries to human and more damages to property as compared to the blast overpressure and shock.

In an ammunition depot layout planning, there are governing safety distance termed as Explosive Safety Quantity Distances (ESQD)[1] which are minimum distance to public access area, minimum distance to inhabitant buildings, and minimum distance to mass public amenities. With these distances, major damage to life and property are protected against the blast, shock, thermal radiation and fragment projectiles. Such distances require large land area as buffer zone.

Individual explosive storage bunkers are also governs by inter-building separation distances. There are minimum distances to the front, sides, and rear

between each individual bunker. These distance are required to prevent sympathetic detonation of neighboring bunkers just in case one of bunker exploded, it does not spread to other bunkers which resulted in a chain of explosion.

One of the major deciding factors in specifying safe quantity distance of an explosion is the throw-out distance of flying fragments or debris caused by the explosion. If the explosive in one of the bunkers exploded, that particular bunker will be blown up into pieces. Pieces and chunks of concrete will be thrown outwards as projectiles which threat life and property.

Since the 9/11 incident, where insurgency threat is not only on military installations, there is a need for the construction industry to review the design and construction practice to accommodate some preventive and safety measures for certain strategic public buildings and facilities. In most instances of blast incidents, the major fatalities on human does not come from the blast overpressure or shock wave but due to flying or falling building debris like glass, wall rubbles and collapsed building elements.

1.2 Problem Statement

Potential explosion site (PES) like explosive stores requires large land area as buffer zone for public safety. This is required to prevent injury to human and damage to property from flying fragments or debris in the event of any blast incident. Major fatalities from accidental or act of terrorism bomb blast are from flying debris of building materials. To reduce land cost for buffer zone and reduce fatality to human there is a need for lighter construction material where the debris throw out distance and impact load can be reduced.

Foam concrete is a type of lightweight concrete that has the potential as an alternative material to normal concrete for this purpose

1.3 Aim and Objective of Research

The aim of this research is to conduct a small scale field blast test on structural models made from foam and normal concrete. Compare the performance of both materials in term of their blast debris properties like debris dispersion, throw distance, shape, size and weight.

The main objective of this research is to study the suitability of foam concrete as an alternative material for the construction of blast related structure in reducing the blast debris throw distance. With the reduction in blast throw distance, buffer safety area around a potential explosion site can be reduced. Lighter mass with lower initial velocity will reduce impact load thus reduce injury on human. Other related objectives are as follows:

a. To acquire knowledge and experience in conducting a field blast test.
b. To have a better understanding on blast debris dispersion.
c. To promote blast related research in Malaysia.

1.4 Scope of Research

The scope of works of this research includes some literature reviews on the relevant subject, preparation of scaled model structures, field blast testing and analysis of results. The scope covers topics on lightweight foam concrete, explosive safety distances, characteristic of blast debris and methods of conducting blast debris analysis.

The scope does not cover in-depth material properties, mechanics of blast, structural analysis and design of reinforced concrete structures.

Three blast tests were conducted at the Malaysian Army Ranges in Kem Asahan, Tangkak, Johor. Two test for lightweight concrete of different density and a test for normal concrete scaled model. The blast tests were recorded using high speed camera. Blast debris are collected and mapped using sector markings. Debris data are recorded, analysed and reported.

1.5 Significance of Research

This research would provide preliminary results that can contribute to the reduction of safety distances and buffer zone. Test result from this research can also be used for further study on applications of lightweight concrete in blast related structures. Experience gained from conducting this research can be used in improving available blast testing standards.

1.6 Research Methodology

This is a blast debris field study with a small scale blast test on scaled structural model made from lightweight concrete and normal concrete. The focus of the research is comparing the performance of both material blast debris in term of throw distance, size and shape. The research covers the following actions:

a. Define the scope of the study
b. Literature review on subjects that is relevant to the study.
c. Project implementation as detailed in Chapter 3.

1.7 Research Implementation Schedule

The estimated time required to complete this research is 10 months, as detailed in Appendix A. The program started in January 2008 and was expected to complete in October 2008. However due to some unforeseen circumstances along the period, some delays occurred, the field blast testing was successfully conducted in October and the report was completed in November 2008.

1.8 Supporting Organization

This field blast testing on structure is not a common test in Malaysia. Blast testing of various scales are often conducted in Australia and the United States, very few Malaysian military personnel and researchers have the opportunity to witness or be involved. The test requires detailed planning, substantial manpower, usage of explosive and special monitoring equipments like high speed video camera. Various organization assistance are sought, which are as follows:

a. School of Postgraduate Studies, Civil Engineering Faculty, University Technology Malaysia.
b. Civil Engineering Dept, National Defence University, Malaysia.
c. Ihsan Team Consultants Sdn Bhd.
d. Malaysian Army Ordnance Corps.
e. Royal Malaysian Army Engineers Corps.
f. Science and Technology Research Institute of Defence (STRIDE).
g. Housing and Planning Dept, Universiti Sains Malaysia.

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