Mansoura Engineering Journal

Volume 18 | Issue 4 Article 1

12-1-2021

Behaviour of Fibrous Concrete Beams under Impact Loading.

Ahmed Abdel-Raheem
Professor of Structural Engineering Department., Faculty of Engineering., El-Mansoura University., Mansoura., Egypt.

Ahmed Badr
Associate Professor., Structural Engineering Department., Faculty of Engineering., El-Mansoura University., Mansoura., Egypt., profdrabadr@yahoo.com

Atef Samir
BSC., Civil Engineering Department., Faculty of Engineering., El-Mansoura University., Mansoura., Egypt.

سلوك وتحليل الكمرات
الخرسانية و الحديدية القياسية
تحت تأثير أحمال الصدم

لقد صاحب التقدم التكنولوجى متطلبات تصميم منشآت خرسانية تتحمل احمال الصدم المختلفة مثل المخازن و المستودعات و أرصفة الموانىء والطرق والمطارات وهناجر الطائرات، وقد استلزم ذلك زيادة الأبحاث والدراسات للوصول إلى أفضل تصميم هندسى لمثل هذه المنشآت .

و هذا البحث يقدم مشاركة فى هذا المجال تهدف إلى تحديد أفضل أنواع الخرسانات التى تتحمل احمال الصدم مع دراسة تأثير إضافة الألياف المختلفة فى النوع والكميه على مقدرة الخرسانة على تحمل احمال الصدم . و كذلك مدى تأثير نوع الحديد ونسبة التسليح فى الكمرات الخرسانيه المسلحه على مقاومة الخرسانه لأحمال الصدم . بالإضافه الى تأثير الجو المحيط ودرجات الحراره المرتفعه الناتجه عن الحرائق على خاصية مقاومة الخرسانة لأحمال الصدم .

و قد اجريت الإختبارات المعملية فى هذا البحث على كمرات خرسانية مقاس ٧٠ × ١٠ × ١٠ سم مرتكزه ارتكازا بسيطا ذات بحر ٦٠ سم . و قد تم تحميل هذه الكمرات بحمل حر يسقط تحت تأثير وزنه من إرتفاعات مختلفه حتى إنهيار العينه .

و قد استخدم لإجراء هذا الإختبار جهاز تم تصنيعه خصيصا لهذا البحث نظرا لعدم وجود جهاز صدم قياسى لإختبار الخرسانة. وقد روعى عند تصنيع هذا الجهاز ضمان سقوط الحمل رأسيا تحت تأثير وزنه على منتصف بحر الكمره .

كما تم تحميل كمرات خرسانيه أخرى بنفس مقاسات ومواصفات الكمرات السابقه بحمل إنحناء أستاتيكى لتعيين المقاومه الإستاتيكيه لتحميل الإنحناء . وكذلك تم عمل مكعبات خرسانيه قياسيه من نفس الخلطات السابقه لتعيين مقاومه الخرسانه لإجهادات الضغط .

و قد تم استخدام نتائج التجارب المعمليه فى محاولة الربط بين مقاومه الخرسانه لإجهادات الضغط ومدى قدرة الخرسانة على تحمل احمال الصدم . و كذلك البحث عن العلاقه بين إجهادات الإنحناء الإستاتيكيه والديناميكيه . بالإضافه الى تقدير قيمه للحمل الإستاتيكى المكافىء للتحميل الديناميكى مما يمكن من استخدام ذلك الحمل فى تصميم قطاعات الكمرات الخرسانيه المعرضه لأحمال الصدم .

وقد توصل هذا البحث الى العديد من النتائج منها توضيح مدى تغير مقاومة الخرسانه لأحمال الصدم طبقا لتغيير نوع الألياف المستخدمه لتحسين تلك الخاصيه . وكذلك بيان كفاءة حديد التسليح بأنواعه المختلفه (حديد صلب طرى - حديد عالى المقاومه) على مقاومة الخرسانه لأحمال الصدم. كما أوضحت النتائج مدى التأثير المدمر لدرجات الحراره العاليه نتيجة تعرضها لحريق مباشر فى إضعاف مقاومة الخرسانه لأحمال الصدم .

هذا وقد أمكن إيجاد علاقة تقريبيه تربط بين مقاومه الخرسانه لإجهادات الضغط ومدى قدرة الخرسانة على تحمل احمال الصدم وذلك لكل نوع من الخرسانات على حده .

C. 2 Dr. AHMED H.A.ABDEL REHEEM[1], AHMED BADR[2], ATEF SAMIR[3]

BEHAVIOUR OF FIBROUS CONCRETE BEAMS UNDER IMPACT LOADING

ABSTRACT

Impact resistance of concrete is considered as one of the most important properties,needed in the design of concrete units subjected to dynamic loading.Therefore continuous studies and researches are still carried out to determine the best technical and economical design for structures under dynamic loading. This paper takes share in this field aiming to study the effect of different types of fibrous concrete on its impact resistance. Also,This studies was planned to find the most economical fibre and its optimum ratio in concrete mix to get the best results of impact resistance of concrete beams which may exposed to flexural impact loading.

Unfortunately,there is no standard method to determine the impact resistance of concrete. Thus, an impact apparatus which constructed specially for this research was used to apply the impact load (freely falling weight) at midpoint of beam's span.

Experimental investigation were carried out on different types of beams (70x10x10 cm.) to determine its impact resistance. Standard cubes were used to determine the compressive strength of the same mixes of concrete under studies.

The experimental investigation, carried out in this research, had been planned, to find the impact resistance of concrete made from local materials which are commonly used,including different types of fibres such as ;HAREX, FIBERGLASS and FLAX monofilaments.

1-) Prof. Dr. of Str. Eng. Dept., Unive. of El-Mansoura
2-) Assoc. Prof. Dr. of Str. Eng. Dept., Unive. of El-Mansoura
3-) B.Sc. Civil Eng., Unive. of El-Mansoura, 1988

This research realized valuable results showing the effect of the type of concrete on its impact resistance. Also, it cleared the great benefit of using fibrous concrete in increasing impact resistance.

1- INTRODUCTION

The impact strength of concrete reinforced with various types of fibres and subjected to impact loading is usually greater than impact strength of plain concrete. The greater energy required to strip or pull out the fibres provides the impact strength.[5],[9].

Also, the resistance of the fibre reinforcement to crack propagation enables the composite to undergo extensive deformation even after the maximum load is reached. This ability to deform while the fibres stretch and debond causes a considerable amount of energy to be expended before the composite fails. The ability to absorb energy depends on the fibre properties and fibre volume. Although, the resisting of fibrous concrete to shattering under impact loading is high, the experimental determination showing the impact resistance and the factors governing it have received little attention.

2- TYPES OF FIBRES

Three types of fibres were used in this research :-

(1) HAREX .

(2) FIBERGLASS .

(3) FLAX .

2.1- HAREX

There are different types of steel fibres, they generally have the same properties but they are differ in shape. This study deals with one type which is known as "HAREX".

HAREX is the commercial name of shells steel fibres which has greater surface area to insure higher bond with concrete and give the concrete better workability than any other type of steel fibres.

2.2- FIBERGLASS

Fiberglass is the commercial name of the cut kiem vaile monofilaments, which is a synthetic fibre. FIBERGLASS is the most expensive synthetic fibre, and is available in the form of cut monofilaments to length of 10 to 20 mm having a diameter of 0.2 to 0.1 mm.

2.3- FLAX

FLAX is the name of an organic monofilaments which is available as an agriculture product. Flax monofilaments is the most cheeper available local fibre, and it is easy to cut to any lengths, but there is no logical control on its diameter.

3- EXPERIMENTAL INVESTIGATION

Types of fibrous concrete of different percentage of fibre

The following three types of fibrous concrete were studied in this paper.:-

(1) HAREX steel fibrous concrete.

(2) FIBERGLASS fibrous concrete.

(3) FLAX fibrous concrete.

Five mixes of each type of fibrous concrete were investigated at different fibre content equal to 1.0%, 2.0%, 3.0%, 4.0% as percentage of cement weight, besides ordinary plain concrete i.e.0.0% .

The main constituents of the concrete mix were :

* 350 Kg cement per cubic meter of concrete.
* Sand : gravel ratio are 1:2 by weight.
* Water/Cement ratios are varied to give an approximate constant slump on the range (3:5)cm for medium workability.

Tests were carried out to find the impact resistance of concrete and compressive strength for each percentage of the fibre.

4- TESTING OF SPECIMENS

Tests were carried out to find the impact resistance of concrete and compressive strength for each investigated mix.

4.1-*Impact test :*

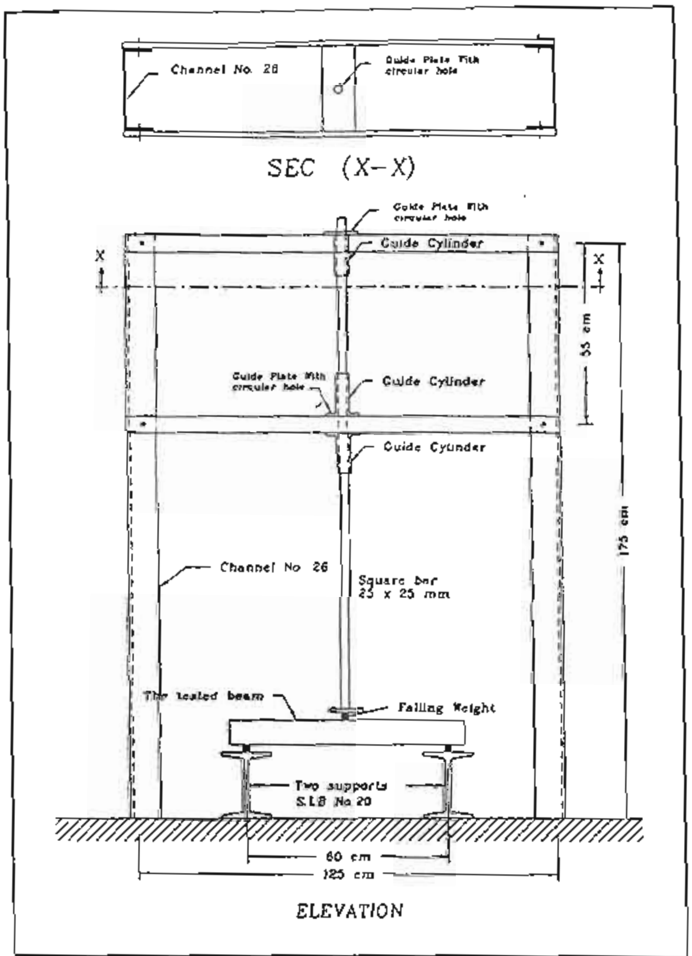

Fig. (1) SKETCH FOR THE IMPACT TESTING APPARATUS.

Impact testes were carried out using falling mass-type impact testing apparatus which is built specially for these research in the laboratory of strength of material ,Faculty of Engineering,Mansoura University. Details of this impact testing apparatus are shown in Fig. (1).

Tests were carried out on (10x10x70 cm) beams specimens, using a falling weight (2.32 kg.).The falling weight is made from available sections and it is consists of circular bar, which gives a line load, attached in a vertical rolled squar bar divided into equal distances, each of them equal 5cm.

The beam is simply supported on a single span equal to 60cm. The beam must be adjusted such that the midpoint of the beam lies vertically under the falling weight and in the same vertical level.

The weight is left to fall freely from successive height starting from a level above the top point of the beam by 7cm. and increased regularly with 5cm. i.e. (h=7, 12, 17, 22, 27 ... .etc) up till failure.

Impact resistance will be calculated by multiplying falling weight with the sum of the different heights till failure as follows :

$$I.R. = W(h_1 + h_2 + h_3 + \ldots\ldots..) \quad \text{Kg.cm.}$$

Where :

I.R. = Impact Resistance kg.cm.

W = Falling weight kg.

h = Height of falling weight cm.

Plate (1)
Impact testing apparatus

4.2-*Compression test :*

The test were carried out on cubes (15x15x15cm) which were prepared and tested according to British Standard Specifications B.S.S. No. 1881.

5- ANALYSIS AND DISCUSSION

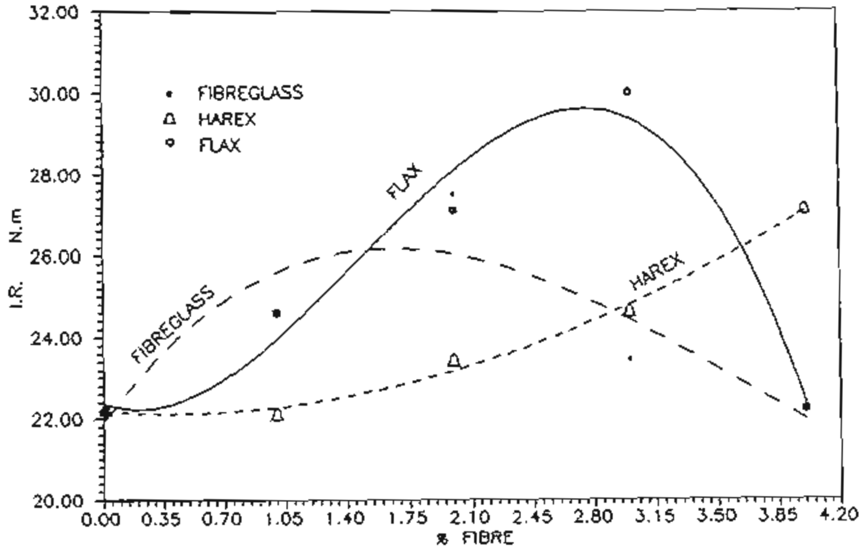

Fig. (2)- Effect of Fibre Content in concrete mix on its impact resistance.

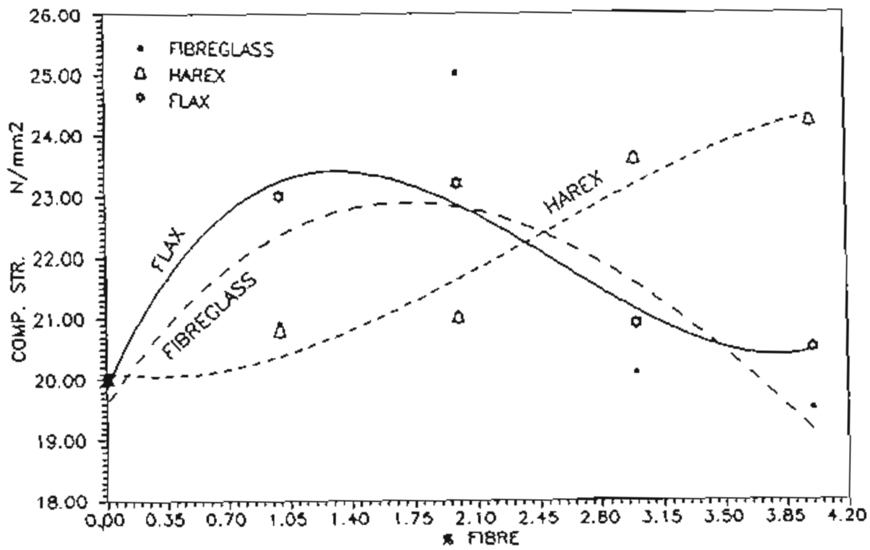

Fig. (3)- Effect of Fibre Content in concrete mix on its compressive strength.

5.1- Effect of Fibre Content

5.1.1- HAREX Fibrous Concrete

Figs.(2)and(3) show that impact resistance, and compressive strength increase with the increase of HAREX fibre content.

The rate of increasing of the impact resistance, and the compressive strength,increases at higher percentage of HAREX fibre content within the investigated limits.

5.1.2- FIBREGLASS Fibrous Concrete

It can be shown from figs.(2)and(3) that the impact resistance, and the compressive strength increase due to increasing FIBREGLASS content up to specific limit at which inflection point occurs. Any increase of fibre content after this limit will produce a decrease of both of the impact resistance, and the compressive strength.

The inflection point is found to be at a fibre content of about 1.75% for both of impact resistance and compressive strength.

If the peak zone assumed to be all values above 95% of maximum value, then the higher values of the impact resistance can be obtained from 0.7% to 2.8% fibre content.Also, the higher values of the compressive strength will be obtained from 0.5% to 3.0% fibre content. Thus, better results may be obtained with FIBREGLASS content from 0.7% to 2.8% as a percentage of cement weight.

5.1.3- FLAX Fibrous Concrete

It was found that both of impact resistance and compressive strength increase with the increases of FLAX content up to specific limit at which inflection point occurs, then any increase of FLAX content will cause decreasing of both the impact resistance and the compressive strength, as can be seen in figs.(2)and(3).

The percentage of fibre content at which inflection point occurs is not the same for both of impact resistance and compressive strength. It was found that compressive strength decrease with the increase of FLAX content than 1.25%. On the other hand,the impact resistance will decrease after a FLAX content of about 3.0% . This decreasing will continue due to any increase of FLAX content.

Also,if the peak zone assumed to be all values above 95% of maximum value, then the higher values of the impact resistance can be obtained from 2.1% to 3.3% FLAX content. The higher values of the compressive strength will be obtained from 0.5% to 2.5% fibre content. Thus, optimum FLAX content may be considered from 2.1% to 2.5% as a percentage of cement weight.

From the above discussion ,it can be concluded that increasing of fibre content may increase impact resistance or compressive strength of concrete up to specific limit after which any increase of fibre content may decrease compressive strength or impact resistance of concrete.

5.2- Effect of Type of Fibre

The effect of type of fibre is differ according to fibre content in concrete. For example, for 1% fibre content it can be seen that find that FIBREGLASS fibrous concrete gives the highest impact resistance over FLAX and HAREX fibrous concrete. Where as at 3% fibre content FIBREGLASS fibrous concrete has the lowest impact resistance as shown in fig.(2).

On the other hand at 1% fibre content the highest compressive strength was obtained from FLAX fibrous concrete where ,HAREX fibrous concrete has the highest compressive strength at 3% fibre content over other types of fibrous concrete as shown in fig.(3).

It can be concluded that a certain percentage of fibre content in concrete could show a higher impact resistance over plain concrete or other fibrous concrete but it may have not the same increase in compressive strength. Thus a specific fibre can be used to improve impact resistance of concrete, where as for improving compressive strength another fibre with different fibre content may be used.

5.3- The Cost of Fibrous Concrete

From the above discussion it may be concluded that several types of fibres can be used to improve impact resistance of concrete. Also, different percentage of specific fibre may be used to get the desired impact resistance. It is knouwn that adding fibre in concrete mix means additional cost. Thus economical factor must be taken into consideration when choosing the type of fibre or its percentage.

Fig.(6) shows the additional cost over the original cost of plain concrete (in L.E.) which will be necessary to get a specific impact resistance using any of investigated fibres (HAREX, FIBREGLASS, and FLAX) according to price list of these fibres in 1992.

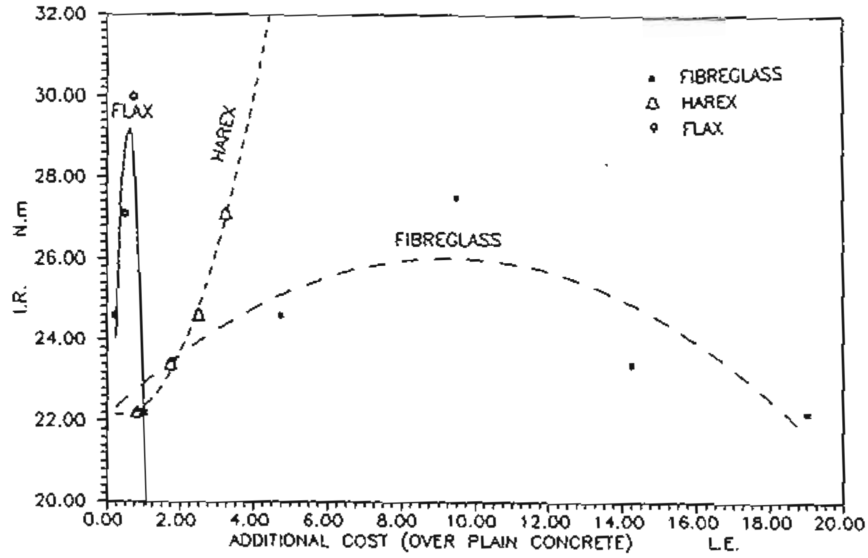

Fig. (6) Relation between desired impact resistance and additional cost (over original cost of plain concrete)

6- CONCLUSIONS

This investigation of fibrous concrete beams under impact loading leads to experimental results which give the following main conclusions :-

All of investigated fibrous concrete types showed a higher impact resistance over plain concrete at different ages

Increasing of fibre content will increase impact resistance of concrete and compressive strength up to specific limit after which increasing of fibre content may decrease compressive strength or impact resistance of concrete or both of them.

At certain percentage of fibre content of a fibrous concrete type could show a higher impact resistance over plain concrete or other fibrous concrete but it may have not the same increase in compressive strength.

The optimum FIBREGLASS content in concrete mix may be considered from 0.7% to 2.8% as a percentage of cement weight. Where, the optimum FLAX content in concrete mix may be considered from 2.1% to 2.5% as a percentage of cement weight.

FLAX fibre was found to be the most economic fibre to get a desired impact resistance up to 300 kg.cm. Also,it was found that if it is required to get impact resistance over 300 kg.cm, then HAREX fibre must be used without putting the economical factor in considration.

7- REFERENCES

1- ATEF SAMIR " Behaviour and Analysis of the beams under impact loading "M.Sc. Thesis, El-Mansoura University,1993

2- Banthia-N. ,Mindess-S., " Impact testing of concrete using a drop weight impact machines " Laval Univ. , Ste-Foy Que.Can.,Mar.1989

3- Hughes-G. ,Beeby -A.-W., "Investigation of the effect of impact loading on concrete beams " Struct. Eng. part B, V 60B ,Sep 1982, p 45-52

4- Ernest K. Scharder ,"Impact resistance and test procedure for concrete " A.C.I. Journal,April 1981, p 141

5- ADAM NEVILLE," Fibere reinforced cement and concrete " RILM Symposium ,Great Britain, September 1975

6- RAY W. CLOUGH,"Dynamics of Structures" Mc.Graw-Hill ,1975

7- R. N. Swamy, "Fibre Reinforced of Cement and Concrete.", Rilem, May-June 1975, p. 235

8- C. D. Johnston, "Steel Fibre Reinforced Mortar and Concrete, A review of Mechanical Properties. " A.C.I. International Symposium, 1974.

9- Dr. M. M. El-Adway Nassef, "Expansive Concrete Reinforced with Nylon Fibres.", JL. Egyptian Society of Engineers, Vol.XIII,NO.3,1973,p.52.

10- Aron, L. Mirsky, "Impact Strength of Concrete.", J. of the A..C. I., Dec. 1965, p. 1606. 06.

11- Egyptian Standard Specifications, "Charpy Impact Test for Metals.", No. 245, 1962.

12- Egyptian Standard Specifications,"Izod Impact Test for Metals.", No. 244, 1962.

13- British Standard Specifications," Methods of Testing Concrete.", No. 1881, 1952.