International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 12 Dec 2021, pp: 862-865 www.ijaem.net ISSN: 2395-5252

Impact Energy Assessment on Rubber-Tyre Concrete using different Methods on Two-Weibull Parameters

A.O. Ibrahim[1], F.O. Adeyemi[2], Y. K. Umar[3], M. Bello[4]and M. Usman[5]

[1,4]Department of Civil engineering, Faculty of Engineering andTechnology,University of IlorinUniversity of Ilorin, Ilorin, Nigeria
[3]Department of Architecture, Faculty of Environmental Sciences,Federal University B/Kebbi, Nigeria
[2]Department of Civil engineering, Faculty of Engineering and Technology, Ajayi Crowther University, Oyo, Nigeria
[5]Department of Building, Faculty of Environmental Sciences, Kebbi State University of Science and Technology, Aliero, Nigeria

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Submitted: 01-12-2021 Revised: 11-12-2021 Accepted: 14-12-2021

ABSTRACT
In this study, an attempt was made to investigate the effect of fire on impact resistance of tyre-rubber concrete (TRC), subjected to drop weight test in accordance with the procedure suggested by ACI committee 544. For this, three samples were prepared from each series of mix containing tyre fibres of 10 mm width and length in various proportions viz., 0%, 2.5%, 5.0% and 7.5%, with a water cement ratio of 0.55. The results obtained were statistically investigated using Weibull Distribution. The Weibull parameters were determined by three estimation approaches; EPM (Energy Pattern Method), Probability Density Function (PDF) and Method of Moment (MOM). Analysis suggested that the three methods are more effective in estimating the weibull parameters. Though there are less differences. Therefore, designers can choose impact strength design value based on the required reliability.
Keywords: tyre-rubber concrete, fire, impact resistance, weibull parameter, EPM, PDF, MOM

I. INTRODUCTION AND CONCEPT

1.1 Introduction

Disposal of waste tyres has become a global problem(Hanbing et al.,2016). In many countries, burying the waste tyres is a common disposal method, which shortens the service life of the burial ground and causes a very serious threat to ecology. Therefore, effectively reusing waste tyres is an urgent and important issue for saving energy and protecting the environment.

Concrete is an essential material in construction(Romeekadevi,2016). The increasing demand of concrete has impacted on the environment ecological balance. Also, the cost of the convectional aggregate is soaring higher. This has led to research for an alternative in the use of natural organic materials, industrial by-products (tyre) in producing lightweight concrete with higher impact energy.

Impact energy of a concrete is the amount of energy absorbed by a concrete when struck by a hard impactor which depends on the contact zone and the impactor.

Bai et al., (2018) observed that many researchers have obtained a lot of research results with the development of fire science theory, which focused on research of heating process of fire district and temperature distribution within the reinforcement and concrete under fire. After fire, the problem concerned by people is the safety of buildings, which is to evaluate the damage of structural component, propose economic reinforcement scheme of repair or removal, reinstate as soon as possible and reduce economic loss.

Murali et al. (2014), investigated the impact resistance of fiber reinforced concrete (FRC), subjected to drop weight test in accordance with the procedure suggested by ACI committee 544. The fibres were varied between 0%, 0.5%, 1.0% and 1.5%, with a water cement ratio of 0.42. The results indicated that incorporating steel fiber to concrete increased the impact resistance and changed the failure pattern from brittle to ductile mode.

Several methods have been proposed for estimating Weibull parameters namely graphical method, Weibull distribution, maximum likelihood method, empirical method, energy pattern factor method, least squares and equivalent energy method. But for this research, Weibull distribution was considered. Weibull distribution is being used to model extreme values such as failure times and fracture strength. Twopopular forms of this distribution are two and three parameter Weibull distributions (Murali et al., 2017).

II. METHODOLOGY

1.1 Energy Pattern Factor Method

The energy pattern factor method is related to the averaged data of impact strength and is defined by the following Equations (1-5), (Murali et al., 2017).

$$\text{Epf} = \frac{N^{3'}}{N^{3}} \quad (1)$$

$$\gamma = 1 + \frac{3.69}{(\text{Epf})^{2}} \quad (2)$$

$$N = \alpha\Gamma(1 + 1/\gamma) \quad (3)$$

where Epf is the energy pattern factor and the gamma function is defined by

$$\Gamma(x) = \int_0^\infty t^{x-1} e^{-t} dt \quad (4)$$

Recall, $\Gamma(1) = \int_0^\infty e^{-t} dt$ (5)

2.2 Method of moments (MOM)

The dimensionless Weibull and scale parameters can be calculated (Murali et al., 2017) as follows and α is obtained from Equation 6-10:

$$\gamma = \left(\frac{0.9874}{\frac{\sigma}{\bar{N}}}\right)^{+1.086} \quad (6)$$

2.3 Probability Density Function (PDF)

$$F_N(n) = 1 - \exp\left[-\left(\frac{n}{u}\right)^{\alpha}\right] \quad (7)$$

Where, n = the specific value of the random variable N;
u = represents the scale parameter;
α = represents shape parameter.

Table 1: Impact Strength of Specimens Under Drop Weight

	No of Blows needed for Failure			
S/ No	F0%	F2.5%	F5%	F7.5%
1	20	20	20	18
2	20	22	22	24
3	20	28	20	18
4	20	22	26	30
5	18	28	26	34
6	20	28	26	34
Mean	19.67	24.67	23.33	26.33
*σ	0.82	3.72	3.01	7.42
**Cov	0.04	0.15	0.13	0.28

**Cov= Covariance, * σ= standard variation; F= % of rubber-tyre replaced

III. RESULT AND DISCUSSION

Table 2 and 3 show the impact energy and parameters values of F0, F2.5, F5.0, and F7.5 at failure stage that was approximately less than or equal to 404.73, 334.15, 465.37 and 328.1 which offers a high reliability. As the reliability curve of plain and Rubber concrete predicts the impact failure strength values, additional cost involved to conduct experiments can be avoided.

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Table 2: Weibull Probability of Survival Distribution

Reliability Level	F0 (kNmm)	F2.5% (kNmm)	F5% (kNmm)	F7.5% (kNmm)
0.99	404.73	334.15	465.37	328.10
0.9	406.13	387.47	467.08	374.65
0.8	406.58	406.24	467.63	390.87
0.7	406.86	418.42	467.97	401.36
0.6	407.07	428.00	468.23	409.57
0.5	407.25	436.31	468.45	416.71
0.4	407.42	444.05	468.66	423.33
0.3	407.59	451.75	468.86	429.90
0.2	407.76	460.10	469.07	437.00
0.1	407.98	470.60	469.33	445.93
0.01	408.39	491.61	469.83	463.73

Table 3: Estimated Weibull Parameters for Comparison

Mix	Parameters (Scale and Shape)	Methods			Average
		PDF	EPM	MOM	
0%	γ	71.4	4.7	31.3	35.8
	α	23.3	19.8	20.1	24.8
2.5%	γ	8.8	4.3	7.9	7.8
	α	23.6	24.7	26.2	23.8
5%	γ	9.8	4.4	9.1	3.9
	α	23.6	23.3	24.6	26.6
7.5%	γ	4.3	3.6	3.9	3.9
	α	24.6	26.3	29	26.6

The Weibull parameters were obtained from the PDF, EPM and MOM methods are shown in Table 3. For example, the γ value for the mix 7.5% PDF, EPM and MOM were 4.3, 3.6 and 3.9 respectively and 24.6, 26.3 and 29 respectively in case of α. The deviation between the γ values obtained from the three methods was very less and the same trend was obtained for remaining mixes (F2.5% and F5%). Hence these three methods are sufficient to estimate the Weibull parameters accurately. Although for plain concrete (0%) the deviation observed for γ was not only due to closeness in the values obtained in the laboratory but also the sensitivity of the methods involved (that is the smaller the coefficient of variation, the larger the deviation in the results).

IV. CONCLUSION

From the drop weight, experimental tests results, it is difficult to choose the design value owing to its lack of reliability which led to increase the probability of failure. In this paper, a proficient and deepened method was employed to analyse the differences in drop weight test results with the aid of two parameter Weibull distribution; also, the impact strength was described interms of reliability level. So, the proposed methods used and validated i.e scale and shape parameters obtained from EPM, PDF and MOM are almost similar. Suitability of these methods and their accuracy are verified. Therefore, these proposed methods to compute the Weibull shape and scale parameters canbe applied to various research areas.

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