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FABRICATION AND RESPONSE REPLICATION OF UNSTRUCTURED AND PRESTRUCTURED MR ELASTOMER AND ELASTOMER USING STEEL NET

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Abstract— The magneto-rheological (MR) elastomeric material has developed addicted to a powerful and cutting-edge smart substance which adjusted and quickly acted upon in relations of mechanical belongings using or deprived of the usage of a magnetic flux. They are made of elastomeric materials with Fe elements incorporated into the medium. Based on the application of a magnetic field during the fabrication process, isotropic and anisotropic MR elastomers are divided into various groups. An elastomer's matrix contains magnetizable particles that are distributed in a highly controlled and kind-organized manner. After observing the structural and behavioral alterations of MREs, another fabrication was made by layering a steel net between elastomeric mediums to replicate the behavior of MREs. Their performance was shown via a Fast Fourier Transform (FFT) analysis. Due to their exceptional mechanical properties, they can be used in a range of applications, including seismic devices, vibration absorbers, and isolators.

Keywords— smart material, magneto-rheological elastomer, carbonyl particles

I . INTRODUCTION

The developing trend of a superior and lax regime has boosted demand for both new technologies and materials, drawing a lot of attention to sophisticated smart and bright functional features. According to Kamila et al., environmentally sensitive possessions are those that are like-minded to ecological elements comprising magnetic flux, mechanical stresses, high temperature, and light (2013). Magneto rheological (MR) resources have become the most significant smart resource due to their enormous economic potential. They are characterized as resources for applied smart materials that exhibit rheological then visco-elastic characteristics like yield plus shear stress as well as damping characteristics in the presence of an external magnetic field. On the other hand, due to the formation of its beautifully polarized particles, MREs can now be divided into two separate sets: isotropic (unstructured) and anisotropic (prestructured). In an isotropic MRE, the polarized elements are uniformly distributed, resulting in physical recitals that are trustworthy in every direction. According to Danas et al. (2012) and Kumbhar et al. (2013), the magnetic elements in an anisotropic MRE are stretched sideways with the input magnetic flux track (2012, 2013). These resources were selected for this investigation. Due to their practical use in vibration absorbing devices and their inherent characteristics under external magnetic flux, Zhou et al. (2014) and Ge et al (2013).

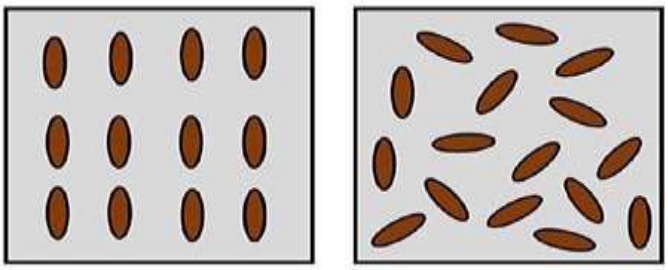

Fig. 1: *Isotropic and anisotropic MRE's*

Preparation of unstructured and prestructured MREs with 350% iron elements by mass of elastomer medium have been done in this revision Kumbhar *et al.* (2012, 2013) and Zhou *et al.* (2014) and Hegde *et al.* (2014). Another preparation was conceded out by setting steel mesh in between the

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elastomeric marix after sighted the structural and behavior alterations of MREs. And, using Fast Fourier Transforms(FFT) examination, observed at models for transmissibility and proportion of vibration concentration Kumbhar *et al.*(2012, 2013). To view the interior morphology of isotropic and anisotropic material materials, SEM examination is required, Ge *et al.*(2013) and Zhou *et al.*(2014) and Khimi *et al.*(2015).

II. FABRICATION OF ISOTROPIC / ANISOTROPIC MR ELASTOMER AND ELASTOMER WITH STEEL NET

An advantageous prestructured magnetic elastomer is an anisotropic magnetic elastomer (MRE). For the period of the curing practice, an exterior magnetic flux is applied to the mixture of magnetic particles and elastomer matrix. One of the most useful unstructured magnetic elastomers accessible is the isotropic MR elastomer. The combination was not subjected to any additional external magnetic flux while it was being cured. According to Kumbhar et al., MRE is an elastomer matrix containing ferromagnetic particles that cures with or without magnetic flux (2012, 2013).. In MRE, which comes in type A (liquid reagent) and type B, iron particles were used with an elastomer matrix that was blended with silicon oil at a ratio of 350 percent by weight (curing reagent). According to Tang et al., the PDMS elastomer was selected due to its straightforward curing process and broad temperature range (2015). Permanent magnets were used to apply a magnetic field during the curing of anisotropic MREs. The cure period was 48 hours for both samples. There are a total of three samples, two of which are MREs that are isotropic and anisotropic. The other, meanwhile, is made of elastomer and steel mesh. 350g of CIP were used to create samples 1 and 2. The type of magnetic flux determines whether there is magnetic flow or not. According to Li et al. (2013), Hiruddin et al. (2014), and Kang et al. (2015), MRE samples 1 and 2 were isotropic (unstructured) and anisotropic (prestructured), respectively (2020).

Table 1: Contented by wt. used for Sample 1 and 2

Model Type	Part-A	Part-B	Si-Oil	CIP	Drying Time
Unstructured & Prestructured MRE	50	5	50	350	48
(Both samples are of same contents, Sample 1 and 2)					

Model 3 has been organized by elastomer by means of steel mesh having weightiness of 20gm introducing in elastomeric medium of weightiness 55gm (50 +5) by 10gm of Si oil.

Table 2: Contented by wt. used for Sample 3

Model Type	Part-A	Part-B	Si-Oil	CIP	Drying Time
Elastomer by means of Steel Mesh	50	5	10	Steel Net=20	48
(In Sample 3, Steel mesh is to be introduced in abode of CIP)					

Figure 2 depicts a actual image of isotropic(unstructured) and anisotropic(prestructured) MRE combined by 350gm of CIP. Fig.3 characterizes a true representation of an elastomer with a steel net.

Fig. 2: *Unstructured (Sample 1) and Prestructured (Sample 2) And Elastomer with Steel net (Sample 3)*

III. RESPONSE ANALYSIS OF MRE's

To ascertain the efficacy of organized MRE samples in terms of transmissibility and percentage of vibration absorption, it was crucial to conduct the investigative investigation, which was briefly mentioned in the study article given. The testing design is depicted in Figure 6. Two accelerometer sensors, a system, an activation table, and a relevant channel FFT make up the test framework. The accelerometers picked up the frequency and amplitude of the vibrations, which the FFT analyzer then captured. Both accelerometer sensors recorded the amplitude force. Both unstructured and prestructured MRE samples were utilized in the experiment, which was run under a variety of conditions. Different loads, notably 0N, 10N, 20N, and 30N, were utilized based on the size of the MRE samples.

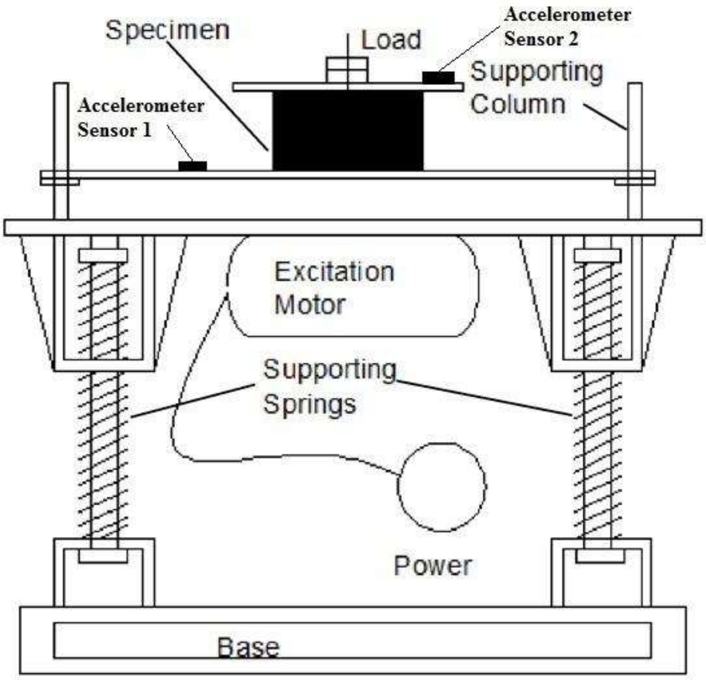

Fig. 3: *Design of Experimental Setup*

Under such load circumstances, the amplitude and frequency of each MRE were examined.

A) Sample 1

Table 3: Outcome table for Model 1

Location	Amplitude	Transmissibility	Vibrat.Absorb %
	Below No Load		
Superior Amp.	7.38	0.793	20.703
Inferior Amp.	9.31		
	Below 10N		

Superior Amp. Inferior Amp.	7.27 9.19	0.791	20.892
	Below 20N		
Superior Amp. Inferior Amp.	6.74 8.57	0.786	21.354
	Below 30N		
Superior Amp. Inferior Amp.	6.58 8.42	0.781	21.853
All interpretation are figured by FFT analyser at 48.3 Hz			

Model 1 using zero load then 10N load condition

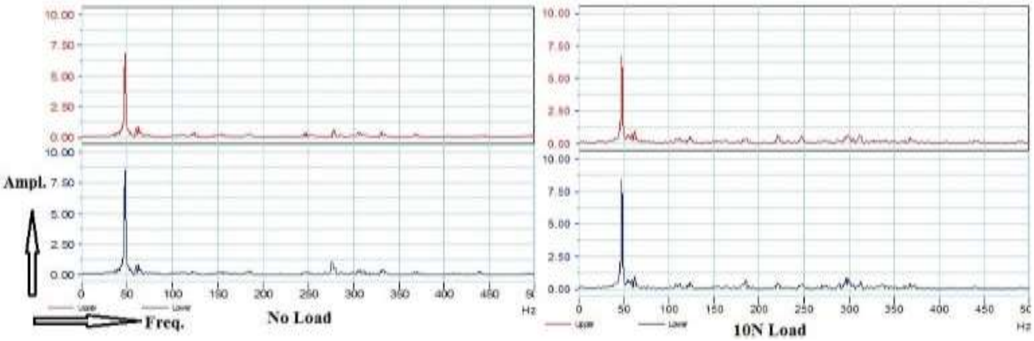

Fig. 4: *FFT diagram for Model 1 with zero load and 10N*

Model 1 using 20N load then 30N loads condition

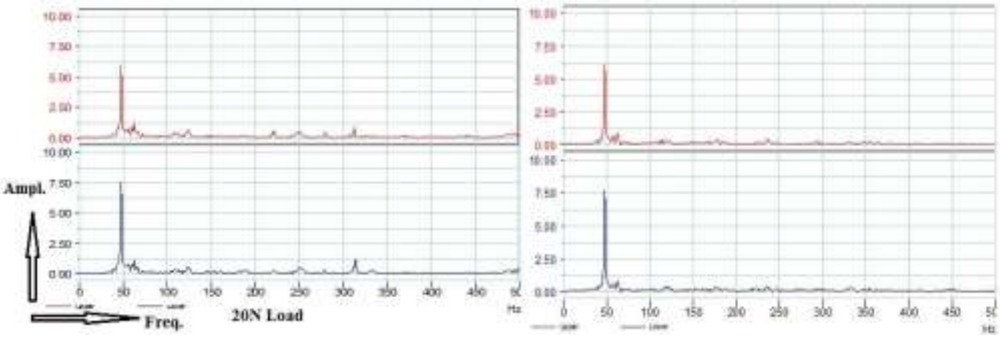

Fig. 5: *FFT diagram for Model 1 with 20N and 30N*

In all loading scenarios, both accelerometer sensors detect the vibration amplitude of both locations at natural frequency 48.3Hz, as seen in the FFT diagram for model 1. From the measured amplitude, the transmissibility proportion and vibration absorption proportions must be calculated. The best outcome in terms of concern objectives is Sample 1's 21.853 percent vibrational absorption and 0.781 transmissibility proportion at 30N load.

B) Sample 2

Both accelerometer sensors pick up the dynamic response of both places at resonance frequencies 48.3Hz under all loading conditions, as the FFT graph for sample 2 demonstrates. The observed amplitude must be used to calculate the transmissibility ratio and percent of vibration absorption. The best outcome in terms of the primary objectives is demonstrated by Sample 2 at no load, which exhibits 21.915 percentile vibration absorption and 0.781 transmissibility ratio.

Table 4: Outcome table for Sample 2

Location	Amplitude	Transmissibility	Vibrat.Abs.%
	Below No load		
Superior Amp.	6.77	0.781	21.915
Inferior Amp.	8.67		
	Below 10N		
Superior Amp.	6.39	0.783	21.691
Inferior Amp.	8.16		
	Below 20N		
Superior Amp.	5.71	0.784	21.566
Inferior Amp.	7.28		
	Below 30N		
Superior Amp.	5.68	0.791	20.113
Inferior Amp.	7.11		
All interpretation are calculated by FFT analyser at 48.3 Hz			

Model 2 using zero load then 10N load condition

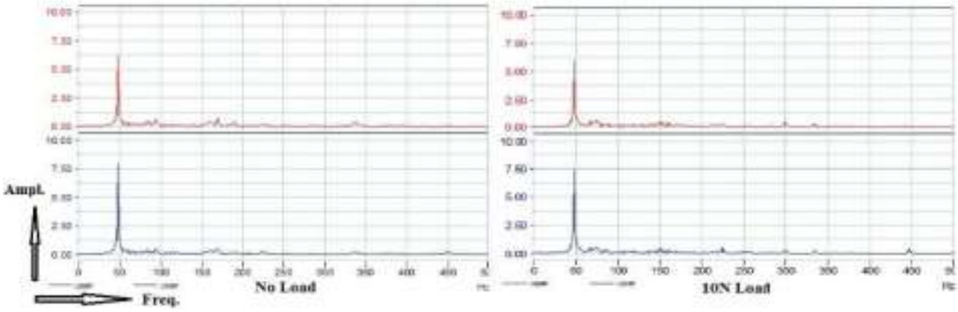

Fig. 6: *FFT diagram for Model 2 with zero load and 10N*

Model 2 using 20N load and 30N load condition

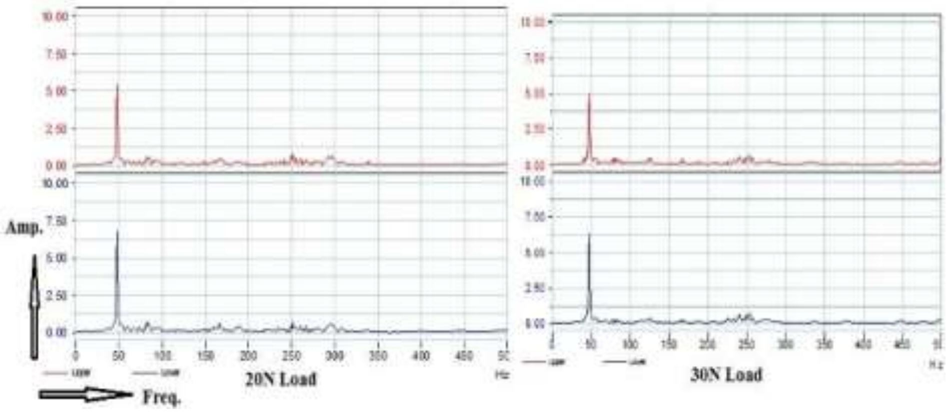

Fig. 7: *FFT diagram for Model 2 with 20N and 30N*

Unstructured and prestructured MRE examples with 350gm of CIPs by weight were assessed for their vibration amplitudes, transmissibility, and vibration absorption percentage. Both samples performed satisfactorily for the parameters examined. A reduced rate of absorption along a material's length is considered transmissible. A low transmissibility ratio and a high absorption rate are necessary for a beneficial outcome. Prestructured MRE outperformed unstructured MRE in terms of MR performance.

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C) Sample 3

Table 5: Result table for Sample 3

Location	Amplitude	Transmissibility	Vibrat.Abs.%
	Below No load		
Superior Amp.	7.19	0.772	22.77
Inferior Amp.	9.31		
	Below 10N		
Superior Amp.	7.08	0.77	22.96
Inferior Amp.	9.19		
	Below 20N		
Superior Amp.	6.59	0.769	23.104
Inferior Amp.	8.57		
	Below 30N		
Superior Amp.	6.46	0.769	23.278
Inferior Amp.	8.42		
All interpretation are calculated by FFT analyser at 48.3 Hz			

Model 3 using zero load then 10N load condition

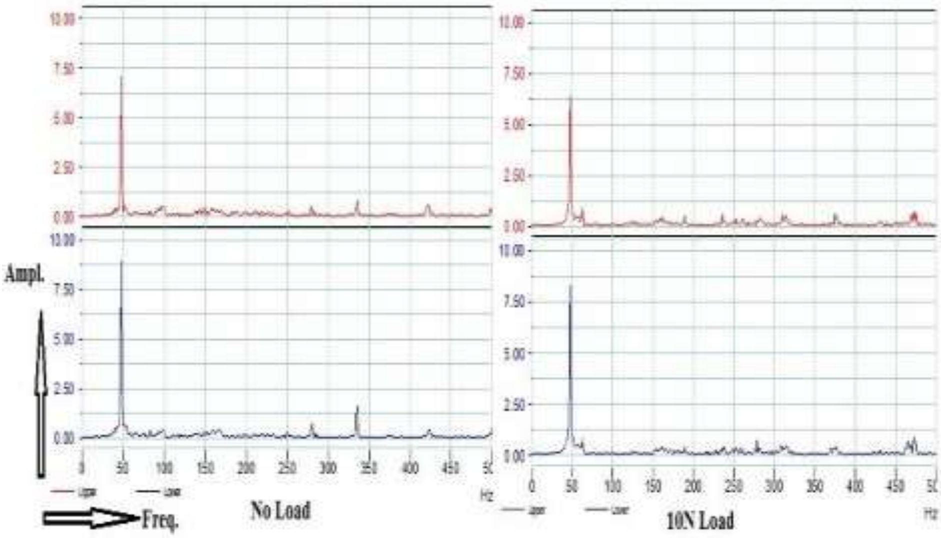

Fig. 8: *FFT diagram for Model 3 with zero load then 10N*

Model 3 using 20N then 30 N load condition

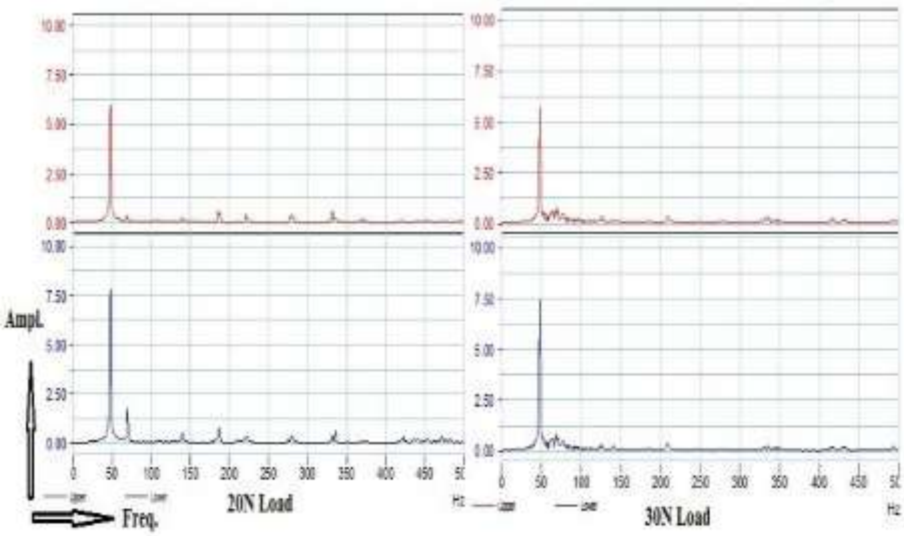

Fig. 9: *FFT diagram for Model 3 using 20N and 30N*

In all loading scenarios, both accelerometer devices detect the dynamic response of both places at natural frequency 48.3Hz, as seen in the FFT diagram for example 3. From the measured amplitude, the transmissibility proportion and vibration absorption fractions must be strong-minded. The best performance in terms of concern objectives is shown by Sample 3 at 30N load, which exhibits 23.278 percent vibration absorption and 0.769 transmissibility ratio. Sample 3 shows excellent results in terms of transmissibility and vibration absorption percentages if compared to the first two MRE samples.

CONCLUSION

In this study, we explored the production, groups, components, and usage of smart MREs. The transmissibility and vibration absorbance percentages are also used to explain the vibration qualities of MREs and elastomers with steel net. In terms of MR performance, prestructured MRE fared better than unstructured MRE. For isotropic MRE samples, after the MRE was verified in the absence of a magnetic field at zero load, 10N, 20N, and 30N loads individually whittled down the lower amplitude of vibration at the same frequency. Transmissibility also decreased as the load enlarged, and the percentage of vibration absorption rose. Additionally, the transmissibility of 10N,20N, then 30N loads rises independently while the amount of vibration immersion decreases as the load increases, precisely as the MR damper was demonstrated with magnetic flux at zero load. Lower absorption along a material's length is referred to as transmissibility. A low transmissibility ratio and a high absorption rate are necessary for a desirable outcome. Sample 3 shows good results in terms of transmissibility and vibration absorbance percentages when comparing to the first two MRE samples. Conclusion: When a low level of seclusion is requisite, an elastomer containing steel net must be chosen for the solicitation since sample 3 is simpler to make than samples 1 and 2.

REFERENCES

[1] Susmita Kamila, “Introduction, Classification and Applications of Smart Materials: An Overview”, *American Journal of Applied Sciences* 10 (8): 876-880, 2013

[2] S. R. Kumbhar, Subhasis Maji and Bimlesh Kumar, “Fabrication and Response Analysis of Magnetorheological Elastomer”, *Material Science Research India*, Vol. 9(1), 111-116, 2012

[3] S. R. Kumbhar, Subhasis Maji, Bimlesh Kumar “Development and Characterization of Isotropic Magnetorheological Elastomer”, *Universal Journal of Mechanical Engineering* 1(1): 18-21, 2013

[4] K. Danas, S. V. Kankanala, N. Triantafyllidis, “Experiments and modeling of iron- particle-filled magnetorheological elastomers”, *Journal of the Mechanics and Physics of Solids* 60, 120–138, 2012

[5] Yanfen Zhou, Stephen Jerrams, Anthony Betts, Lin Chen “Fatigue life prediction of magnetorheological elastomers subjected to dynamic equibiaxial cyclic loading” *Materials Chemistry and Physics*, vol. 146 , 487-492, 2014

[6] Lin Ge, Xinglong Gong, Yanceng Fan and Shouhu Xuan, “Preparation and mechanical properties of the magnetorheological elastomer based on natural rubber/rosin glycerin hybrid matrix”, *Smart Materials and Structures* 22, 115029 (8pp), 2013

[7] Sriharsha Hegde, K.V. Gangadharan, **“**Testing of RTV-Silicone based thick magneto-rheological elastomers under harmonic loading conditions” *International Journal of Scientific & Engineering Research*, Volume 5, Issue 2, ISSN 2229-5518, 2014

[8] S. Raa Khimi, K. L. Pickering, “Comparison of dynamic properties of magnetorheological elastomers with existing antivibration rubbers”, *Composites Part B*, 2015

[9] Benxiang Ju, Rui Tang, Dengyou Zhang, Bailian Yang, Miao Yu, Changrong Liao, “Temperature-dependent dynamic mechanical properties of magnetorheological elastomers under magnetic field”, *Journal of Magnetism and Magnetic Materials*, 374, 283–288, 2015

[10] Weihua Li, Xianzhou Zhang, Tongfei Tian, and Weijia Wen, “Fabrication and characterisation of patterned magnetorheological elastomers”, *AIP Conference Proceedings* 1542, 129, 2013

[11] Khairunnisa Hairuddin, Saiful Amri Mazlan, Ubaidillah, Hairi Zamzuri and Norazman Mohamad “A Feasibility Study of Magnetorheological Elastomer Base Isolator” *Applied Mechanics and Materials*, Vol. 660, 763-767, 2014

[12] Sung Soon Kang, Kisuk Choi, Jae-Do Nam and Hyoung Jin Choi, “Magnetorheological Elastomers: Fabrication, Characteristics, and Applications”, *Materials 2020*, 13, 4597, 2020