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UTILIZATION OF NON-NEWTONIAN LIQUID TO FILL POTHOLES

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Abstract: A system and method to fix cracks and void: caused due to deterioration of roads is thus needed. This method employs filling the potholes by putting flexible container, mainly a bag which is filled by a Non-Newtonian fluid which has shear thickening properties. This method is economical, relatively less taxing than the conventional methods of repairing the potholes. It is also environment-friendly as the fluid is organic. The objective is to provide a superior and mobile solution to a long standing and often ignored problems of potholes that exists everywhere. The project aims to engineer the fluid by necessary mix proportion based on the types of traffic, its frequency and climatic conditions to obtain the highest level of performance from the product itself. Some of the applications of Non-Newtonian fluid are thixotropic, liquid amour, sport shoes and viscous coupling. Due to its advantages over conventional materials like it's not needed to be casted, can be used directly, mobile, time saving, cost reducer in terms of labor and capitals, its better than conventional potholes filling methods. The effect of weathering and decay on the sample results in some amount of loss of strength. The range of loss varies between 3% to 6 % for a weathering and decay period of 7 days. The site test and demonstration of the unit proved to be successful and as predicted by the different loading conditions and fluid properties. The loads of bags were gradually increased. First a two-wheeler was passed over it and shows no sign of shock. Then the same was repeated with a four-wheeler car and then finally with a truck. The observations can make us conclude that the unit bag was successfully resisting the loads from these vehicles and thus cleared site test.

Keywords: Potholes, shear thickening, Non-Newtonian fluid, Flexible container, Compressive strength test

1. Introduction

A profound common underground cavern shaped by the disintegration of rock, particularly by the activity of water or a downturn or empty in a street surface brought about by wear or subsidence. The exceptional improvement of potholes during the 2209/2010 summer precipitation season on especially the Indian common and metropolitan streets with bituminous surfacing prompted boundless worry among street clients and huge media revealing[1].

Various cases were laid against street experts for vehicle harm brought about by potholes and in any event, for genuine vehicle mishap coming about because of unnecessarily huge potholes. Potholes have consistently been an issue on fixed/cleared streets.

The real expenses of potholes in Indian regarding harm to vehicles and mishaps caused straightforwardly by potholes and other street client's impacts have not been qualified, however likely run into a large number of rupees. It ought to, nonetheless, be noticed that this issue isn't special to India.

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The primary target in diminishing pothole arrangement is consequently to guarantee that preventive support is applied hesitantly and proper principles. For a long time to come, in any case, this is probably not going to be accomplished completely and ideal methods for fixing potholes ought to be executed[2]. Most of streets in India are surfaced with bituminous surfacing, which are more inclined to potholing than solid streets, in spite of the fact that potholes can and do shape in solid streets.

Brihanmumbai Municipal Corporation (BMC) has spent Rs. 11,000 crores to give you pothole-ridden in the course of recent years. The BMC had a budgetary arrangement of Rs. 14500 crores for fix and remaking of streets from 2011 AND 2016, of which it spent Rs 11,000 crore. That is not all, it has got Rs 5183 crore for the work distributed in the financial plan for 2016-17. It will likewise spend an extra Rs. 2000 crore on the maintenance of in excess of 1000 streets, which is in progress. Specialists and activists track down the number hard to grasp. On the off chance that Mumbai – Pune express way, which goes through a troublesome landscape, could be worked at an expense of Rs. 1600 crore and stay in great condition in spite of dealing with 12,000 vehicles day by day, for what reason wouldn't we be able to improve city streets at multiple times the expense, they inquire[3]. Not simply street fixes and remaking, the BMC has spent Rs. 218 crores on filling potholes in the previous five years. On the off chance that streets are made according to the norms, potholes ought not surface. There are urban communities that got more downpour than Mumbai, yet at the same time have without pothole streets. Burning through cash on an impromptu premise isn't the arrangement.

The most straightforward deviation from the Newtonian liquid conduct happens when the easiest shear information σ–doesn't go through the inception and additionally doesn't result into a direct connection between and. Then again, the clear consistency, characterized as/. Isn't consistent and is capacity of or. For sure, under suitable conditions, the obvious thickness of specific materials isn't just a component of stream conditions (calculation, pace of shear, and so on), however it likewise relies upon the kinematic history of the liquid component viable.

Non-Newtonian fluid does not need to be casted like concrete. It does not need to be prepared on site like asphalt mixes and can be directly used as a unit that has been manufactured before. The unit of the bag filled with the non- Newtonian fluid is easily mobile and very convenient to carry at the site. The unit is very time saving as it just has to be placed in a pothole and camouflaged with a polymer sheet and no need of actual carrying out of work like asphalt/bitumen mixing, laying and concrete casting at the affected area. Use of the non-Newtonian fluid bag unit covered with a polymer sheet meant only for camouflage is also better in aesthetics than conventional pothole filling methods.

2. METHODOLOGY

2.1. Analysis of acquired data

We have studied different traffic loading conditions pertaining to our project and based our mix proportions on those values. The major requirement for preparation of mix proportions is to analyze the axle loads on a pothole or section of a road and thus evaluate whether a certain type of mix might be able to sustain the loads in its useful life.

2.2. Specimen Preparation

2.2.1Sampling of materials

The materials used to prepare the Shear thickening non-Newtonian fluid are cornstarch and water. They are to be mixed as per volumetric proportions but for convenience in preparation they need to be weighed

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for which the density and ratio should be calculated. This was done by weighing a sample of cornstarch filled in 100 ml cylinder. It was found to be 80 grams per 100 ml.

Density of Cornstarch= Wt. of Cornstarch/Volume

= 80/100

= 0.8 gm/cc.

= 800 Kg/m^3

Sampling was done by preparing mixes of

1. 2:1
2. 1.5:1

The best workable mixes were chosen as final mix proportions to be filled in the bags. These were 2:1 and 5:1 where the larger quantity is cornstarch.

2.2.2. Weighing of materials

The specimens were prepared by weighing the cornstarch and water and mixing them thoroughly. For 2:1 volumetric ratio, and considering 2.5 liters of fluid the weight required of cornstarch is as calculated below:

1. One part =2.5/3=0.833 liters
2. Volume of cornstarch = 2*0.833 =1.66 liters
3. Weight of cornstarch = density of cornstarch * volume

   = (800*1.66)/1000

   = 1.32 Kg

   Therefore, Wt. of Cornstarch = 1.3 Kg
4. Volume of water = 0.833 liters
5. Weight of water = 0.833 = 0.9 Kg.

The specimens were prepared by weighing the cornstarch and water and mixing them thoroughly. For 1.5:1 volumetric ratio, and considering 2.5 liters of fluid the weight required of cornstarch is as calculated below:

1. One part = 2.5/2.5 = 1 liter
2. Volume of cornstarch = 1.5*1 =1.5 liters
3. Weight of cornstarch = density of cornstarch * volume

   = (800*1.5) /1000

   = 1.2 Kg

   Therefore, Wt. of Cornstarch = 1.2 Kg
4. Volume of water = 1 liter
5. Weight of water = 1Kg.

Similarly, the weight and volume of individual materials can be calculated based for any mix proportion.

2.3. Manufacturing of containment bag

The bags to be filled with the fluid are made of tarpaulin sheets having a thickness of 300 GSM and the size of bag is 250*200 mm. this material for the bags was chosen based on its cost and properties[8]. For higher strength and good joints PVC bags can be used but economy will be compromised a bit.

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2.4. Filling of the mix in bags

The mix of proportions 2:1 and 1.5:1 having 3 samples each of filled in tarpaulin bags which were sealed from 3 sides before filling and then sealed from the 4^{th} and last side of fluid was filled. The bags were sealed in such a way that they are water and air tight and allow no passage of any natural or artificial element. Thus making sure that the contents of the bags remain unaffected.

2.5. Testing

2.5.1. Compression test

In this test the unit of bag filled with the Non-Newtonian fluid is subjected to gradual compression loading from Universal Testing Machine (U.T.M).

2.5.2. Decay test

In this test a sample of the fluid with standard mix proportions is prepared and left open to atmosphere for 10 days and the condition of the fluid is then evaluated.

Site test and live demonstration: In this test the unit of bag filled with the Non- Newtonian fluid is placed in pothole of appropriate size and it is tested by being run over by vehicles of increasing loading.

3. REPORT ON INVESTIGATION.

The presence of water is the fundamental driver of potholes; their course of action differentiations somewhat dependent upon the road black-top construction and materials used. Potholes can, clearly, moreover result from various, non-hidden causes like diesel (or other manufactured) spillages; mechanical damage to surfacing from vehicle edges and also disasters and flares; hurt achieved by falling rocks in cuttings; animal hooves on road surfaces in warm environment, and vulnerable road plan over certain sub assessments, for instance wide, collapsing and dispersive soils. The predominant piece of potholes structure in the wet or swirling season, yet it isn't extraordinary for potholes to make and debilitate during the dry season on account of not simply the movement of traffic, yet also concise wet conditions coming about as a result of limited water framework, ponding or possibly seepage of water, etc The last can regularly be perceived by the presence of water-revering (hydrophilic) plants around there [4].

Potholes furthermore happen for the most part due to powerless restoration of organization channels that are uncovered through bituminous-surfaced roads. These are made do with autonomously in this report. Potholes may be joined by outrageous breaking likewise, turning or mutilation of the surfacing around the pothole, showing a more significant arranged justification the pothole advancement. Where little bending is seen close by the pothole, the explanation will undoubtedly be the segment of water through surficial breaks in the road black-top and deterioration of simply the surfacing and upper essential layers of the black-top. Fundamental differentiations in pothole improvement rise up out of whether the bituminous black-top surfacing is dark top or then again a slight bituminous-surfacing seal (secretly called chip and shower', surface dressing, surface treatment or chip seal).

3.1. Mechanism of pothole development

An all-around developed and kept up, unblemished. Adaptable bituminous seal ought not make potholes, makes potholes. It may deform as the secret laver misfires, yet without the improvement of breaks in the seal or real loss of the seal, potholes will not make. Protection of the seal in a good condition (with standard use of fog sprinkles moreover, reseals) will subsequently avoid the plan of potholes. A large portion of potholes in roads are connected with wet conditions, while water in the black-top plan will just to a great extent cause torment or potholes without the utilization of weights from vehicles. At the point when the black-top is stacked, shear dissatisfaction of the material in contact or close to the stacked tire will occur. This is achieved by the applied nerves outperforming the shear strength of the material, which

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at this stage is ordinarily doused what's more, presented to incredible tensions with high pore-water pressures (a wonder exacerbated by quick stacking).

In case the material is simply wet and not doused, anyway the supreme pressing factor applied by the wheel load outperforms the strength of the material, shear dissatisfaction may moreover occur - the misery molded thusly by and large prompts a pothole as time goes on[7] . It is now and again seen that the uncovered material in potholes starts to ravel (especially when the flexibility is low) and de-thickness as the pothole extends. This material, isolated from having a low shear-strength, is furthermore responsible to whip-off and loss of material from the pothole under rapidly moving traffic. Despite the prompt pressing factor/stacking impacts, it is moreover possible that the seal/base interface gets crippled and more slanted to scratched region under wheel advancement, achieving improvement and stretching out of the pothole. As the pothole turns out to be more significant, the impact of vehicle tires on the pathetically maintained edge of the pothole achieves breakdown or disintegrating of the seal and accelerated intensification of the pothole to possibly unsafe conditions.

Area of potholes

The genuine space of potholes inside the road carriageway can be a useful indication of the beginning stage or justification the pothole. The greater part of potholes seem to occur in the outer wheel methods of single carriageway roads inciting expansive fixing [6]. These can generally speaking be credited with the effects of extended moistness in the sub level and black-top layers during the wet season. This results from periodic suddenness changes inside the outside 600 to 1 200 mm of the carriageway, as depicted by Emery (1992). This effect is likely exacerbated by the extra store on the outside wheels of considerable vehicles in light of the road camber.

CALCULATION AND RESULT

Compression Test on Universal Testing Machine (UTM)

Proportion Ratio:

1. 2:1 (2 part of cornstarch & 1 part of water) 2.5 Kg. of Bag.
2. 1.5:1 (1.5 part of cornstarch & 1 part of water) 2.5 Kg. of Bag.

Table : 1 compression test

Sr. No.	Sample 1	Sample 2	Sample 3	Average LOAD
Compression Load on (2:1) bag	130.4KN	128.5 KN	125 KN	127.9 KN
Compression Load on (1.5:1) bag	138.6 KN	130.8 KN	135.5 N	134.9 KN

Size of the bag = (250*200) mm

Area of the bag = 50000 sq. mm

Compressive Strength of the Bag filled with Non- Newtonian Fluid:

For proportion (2:1)

Compressive strength = Compressive force/Area

= 127.9*1000/50000

= 2.558 N/mm^2

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For proportion (1.5:1)
Compressive strength = Compressive force/Area
= 134.9*1000/50000
= 2.698 N/mm^2

Table No.2. - Result of Compression Test

Sr. No.	Proportion	Wt. of Sample	Compressive Strength
1	2:1	2.5 Kg	2.558 N/mm^2
2	1.5:1	2.5 Kg	2.698 N/mm^2

CONCLUSION

From the above results we can conclude that the unit weight of bag filled with Shear Thickening non-Newtonian fluid can successfully be used as a temporary method of fixing potholes. The compression test results show that a maximum strength of 134.9 KN can be achieved while the corresponding stress is 2.698 N/mm^2.

The effect of weathering and decay on the sample results in some amount of loss of strength. The range of loss varies between 3% to 6% for a weathering and decay period of 7 days.

The site test and demonstration of the unit proved to be successful and as predicted by the study of different loading conditions and fluid properties. The loading on the bags were gradually increased. First a two-wheeler was passed over it showed no signs of shock. Then the same was repeated with a four-wheeler car and then finally with a truck. The observations can make us conclude that the unit of bag was successful in resisting the loads from these vehicles and thus it cleared the site test.

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