Vacuum Dewatered Cement Concrete Roads – A Review

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***Abstract* – Bad roads leads to many fatalities every year globally. Therefore, it is important to search for innovative ways for maintaining the sustainable management of good roads. According to a report of Ministry of Road Transport and Highway, about 3000 fatalities occur annually in India. Thus, in any road construction, flooring work plays an important role and should be in fact time efficient with medium to high workability. In the present paper, an attempt has been made to understand a safe, healthy and comfortable concrete flooring through a technique called vacuum dewatering concrete flooring (VDF) technology. This process efficiently removes excess water from newly placed, compacted and levelled concrete surfaces. This dewatering will help in better compaction, improve physical behaviour of concrete and also aid in better performance of the road post construction. This method is nowadays widely used in warehouse concrete flooring, concrete road, parking area, production area in industrial buildings etc. This paper also provides a review on concrete flooring of roads using vacuum dewatering concrete technique/tremix method along with its advantages & dis-advantages.**

Keywords- vacuum dewatering concrete; civil structure; technologies; tremix method

I. INTRODUCTION

A vacuum dewatering concrete flooring/tremix method can be defined as "Vacuum Dewatered Flooring is a special type of Flooring Technique to achieve High Strength, Longer Life, Better Finish and Faster Work. This type of floor is suitable for high abrasion & heavy traffic movement" (Singh et al, 2019). Pot holes in a road has led to many accidents and loss of lives. A report from the Ministry of road transport and highway gives a statistics of the number of accidents and fatalities in the past 6 years (Table 1). Such problems can be avoided if the construction of the road is done scientifically with all precautions. Vacuum dewatered cement concrete (VDCC) roads reduce potholes and in turn reduce/avoid accidents by increasing the compressive strength of concrete roads.

Table 1: Road transport accident due to potholes and fatalities statistics

Year	No. of Accidents	Fatalities
2014	11106	3039
2015	10876	3416
2016	6424	2324
2017	3597	3010
2018	4869	3500
2019	4800	>2500

After, Ministry of Road transport and Highways

The vacuum dewatering method was first initiated and patented by United States of America nearly half a century ago. In the recent years, this method is applicable in several Scandinavian countries and in Sweden, this method is used for more than half of the concrete roads constructed till date. With the advancement of time, the equipment is simplified enough to make it practical for almost all type of construction. Basically, this process improves strength, durability, and other properties of concrete by reducing the water-cement ratio immediately after the mix is placed, usually in floors and other flooring purposes. This method is also called as Tremix named after the inventor, A B Tremix (Patel et al, 2015). Tremix or vacuum dewatering flooring is popularly known in India, is actually Vacuum dewatering process of concrete. It was originally invented by Tremix AB, Sweden many years ago. This process was introduced in India by Aquarius Technologies in 1987. In 1991 to start production of Vacuum System in India, it became so popular in India that almost everybody related to concrete flooring industry, such as manufacturers/ contractors/ consultants started calling this process by the name of its inventor. The layout of the VDF is as shown in the figure below (Fig.1).

II. LITERATURE REVIEW

Various researches have worked on the efficiency of VDF. Singh, et.al, (2019), have discussed about the study of concrete on the application of vacuum dewatering process. The authors opine that this technology is a new way of concrete flooring in civil construction works with more advantages in it and suggest that this is one of the innovative technique to avoid pothole problems. Patel, et.al, (2015), has studied about the innovative flooring works in civil structure and opine that Vacuum dewatered cement roads provide a comfortable, safe and healthy concrete flooring. The authors also say that this process efficiently remove excess water from newly placed, compacted and levelled roads. Meshram and Budlani (2020), have studied the efficiency of tremix method for solid flooring and say that as the water concrete proportion influence the quality of the solid however for the ground surface, the main plain cement concrete work for the better appearance. Dongxu and Xuequan, (2003), has discussed about the influence of fast-setting/early-strength agent on the high-content phosphorous slag cement (PHSC) by conducting the strength tests, setting-time test, pore-structure test and XRD analysis. The components and hydration of fast-setting/early-strength agent had also been studied. Many other researchers like Sancak (2008);

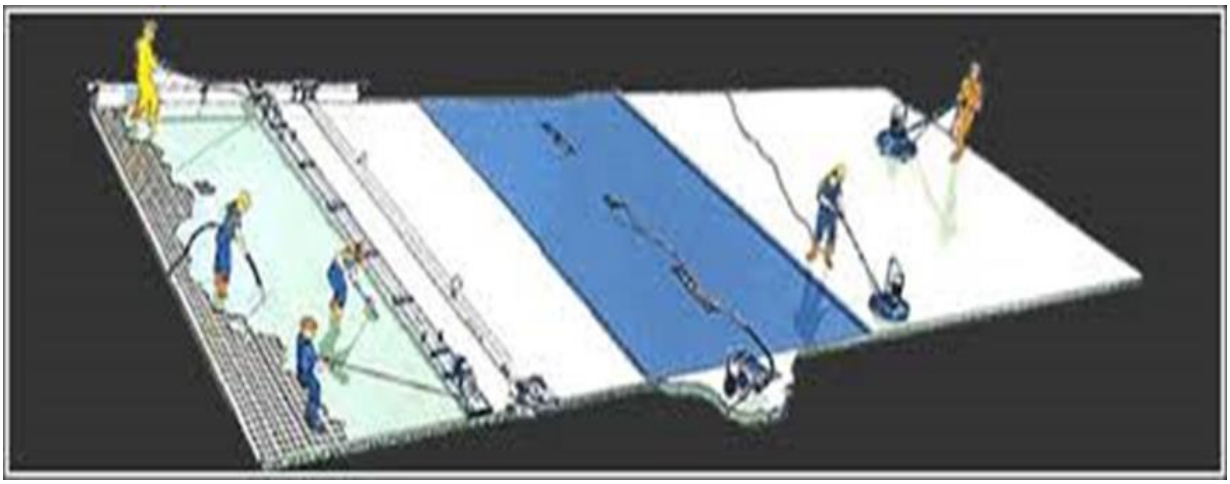

Fig.1: Layout of Vacuum Dewatering Flooring. Source weblink:

Subhash et.al (2019); Pickard, SS (1981) have explained the use, compressive strength, early setting time, workability and other aspects of this technique. Naveen et.al, (2018) has mentioned that the potholes not only damage the vehicle but also cause serious vehicle accidents. According to the survey conducted by the automobile association and quoted by Hegde et.al (2014) is that people tend to lose balance when they come across a larger pothole. Baskara et.al, (2016) has reviewed the rate of accidents and pavements conditions. Others Researchers like Szymanski et.al (2017); Lili (2016); X.Fu et.al (,2018); Wang et.al, (2020) have studied and reviewed the innovative techniques in road construction, detection and segmentation, use of cement concrete pavements conditions and accident conditions etc.

III. COMPARISON OF VDF AND CONVENTIONAL CONCRETE

The water added to a concrete mix generally exceeds the optimum required amount of water to fully hydrate the cement constituent. In VDCC method, the chemical reaction of cement with water requires a water-cement ratio of less than 0.38 (Avitesh and Saifi, 2017). The additional water present after the satisfaction of water: cement is utilized as lubrication medium to allow mixing, placing, levelling and consolidation. In conventional concreting practice, an important challenge is the prevention or limiting of evaporation of mixing water out of the freshly placed concrete so that workability of the concrete is maintained. The uncontrolled removal of water from the concrete matrix can result in adverse effects such as plastic shrinkage cracking. Excessive bleeding of concrete can negatively interfere with surface characteristics such as resistance to wear. Concreting in areas exposed to the natural elements like sun and air, that is in hot and windy conditions poses even higher demands in order to produce quality, durable concrete. However, vacuum concrete is the effective technique used to overcome this contradiction of opposite requirements of workability and high strength. This process efficiently removes excess water from newly placed, compacted and levelled concrete surfaces. Vacuum treatment of concrete has been refined to specially address the concreting of large exposed surfaces in hot weather conditions. It renders an economical, time-efficient compaction technique to concrete that can be placed on a medium to high workability.

Vacuum treatment of concrete gives better results with Portland cement. The results show a marked increase in compressive strength (Ankit Kumar Singh, et.al,2019). In general, compressive strength of vacuum dewatering processed concrete is 25-45% higher at 28 days after casting (Meshram and Budlani, 2020). Vacuum dewatering greatly improves the abrasion and impact resistance of the concrete surface (Patel, et.al, 2015). The vacuum dewatering results in coarse aggregate in the fresh mix being drawn to the top surface a further contributing factor in achieving wear-resistant concrete surfaces the surface of vacuum treated concrete is free of pitting, an important consideration for abrasion resistance and the possible exposure to a continuous flow of liquid over the member. Durability considerations include the improved impermeability, higher density, lower absorptiveness and reduced shrinkage. Below the shown the condition of concrete floor before & after vacuum dewatering concrete flooring. Figure 2 gives a schematic representation of the binding process of VDCC.

IV. VACUUM DEWATERING PROCEDURE

The vacuum dewatering process removes surplus water present in the concrete. This is done using the Vacuum Equipment comprising of Suction Mat Top Cover, Filter pads and Vacuum Pump. The process starts immediately after surface vibration. Filter pads are placed on the fresh concrete leaving

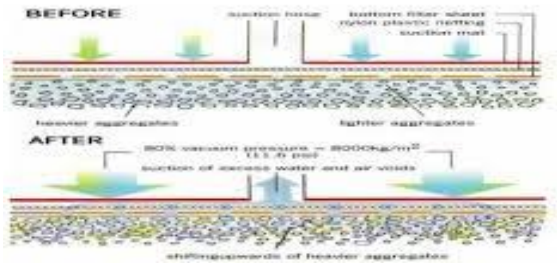

Fig.2 Condition of concrete before and after VDF. Source weblink:

about 4 inches of fresh concrete exposed on all sides. The top cover is then placed on the filter pads and rolled out till it covers the strips of exposed concrete on all sides. Further, the top cover is connected to the vacuum pump through a suction hose and the pump is started. Vacuum is immediately created between the filter pads and the top cover. Atmospheric pressure compresses the concrete and the surplus water is squeezed out. This process lowers the water content in the concrete by 15-25% (Patel, et.al, 2015). The dewatering operation takes approximately 1.5 - 2 minutes per centimetre thickness of the floor. The dewatered concrete is compacted and dried to such an extent that it is possible to walk on it without leaving any footprints. This is the indication of concrete being properly dewatered and ready for finishing. Figure 3 shows the schematic diagram for vacuum dewatering process.

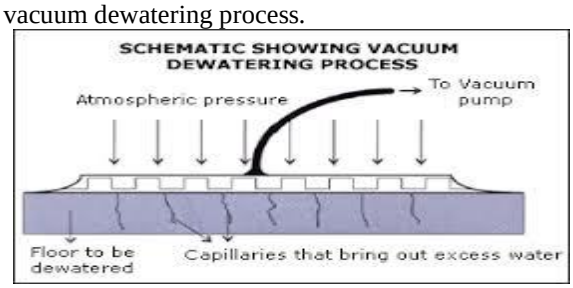

Fig. 3: Schematic diagram for vacuum dewatering process. Source weblink -

The equipment to be used during this process include:

A. Double beam screed vibrator

The screed vibrator shall be self-travelling and shall require guiding along the formwork dragged by two operators. It shall be light weight with high quality heavy duty spring steel and shall be electrically driven. Overall length of the vibrator is 4200mm, width is 410mm, height is 125mm, total weight of the screed vibrator is 128.5kg. Power unit required to drive motor is 2 H.P.

Fig 4: A double beam screed vibrator; source weblink:

B. Vacuum pump with Hose

It shall enable fast and easy removal of excess water from the freshly laid concrete after compaction and levelling thus allowing floor finishing within 45 minutes of placement of concrete. It shall be electrically operated self-contained units powered by minimum 7.5 H. P electric motor mounted on a transportation trolley. It shall be capable of dewatering at least approximately 35 sqm in one operation. Length of the vacuum pump is 2200mm, width is 660mm, Height is 880mm, Weight of pump is 320kg, pump capacity noted as 110m/Hr. Power unit to drive the motor is 7.5 H.P.

Fig.5- A Vacuum pump; Source weblink - data:image/jpeg;base64

C. Suction mat

The suction mat incorporates the use of large single PVC sheet beneath which is placed with honey combed plastic clothes having an under surface nylon cloth to act as very fine filter. Figure 7 shows the filter mat. Top mat (Figure 6) is provided with a short hose. Mat size may be of 7.5x5m or as required for the panel size.

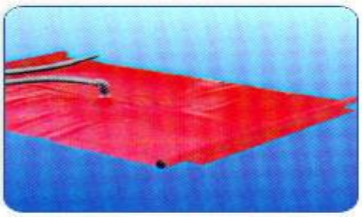

Fig.6-Top mat; Source weblink-

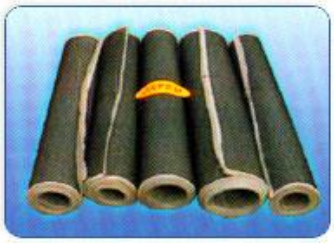

Fig.7-Filter mat; Source weblink-

D. POWER FLOAT

It is surface grinding equipment powered by the standard 3 horse power (HP) electric motor. It grinds the surface to make it wear resistance and shall also remove surface modulation prior to final finishing. Overall height of power floater is 980mm with floating speed of 120 RPM overall equipment weight is 140kg with disc weight of 390kg.

Fig.8- Power float, source weblink- https://encryptedtbn0.gstatic.com/images

E. POWER TROWEL

It is surface finishing equipment, powered by standard 3.0 HP electric motor. It polishes the surface after floating operation. Two passes are suitable for non-dusting floors. Overall height of trowel is 980 mm with troweling speed of 120RPM overall equipment weight of 145kg with working diameter of 910mm.

Fig.9- Power trowel; Source weblink-

V. ADVANTAGES OF VDCC

- Increase in compressive strength of concrete by 25-45%.
- Reduction in w/c ratio leads to early setting and high strength.
- This system removes the excess water after pouring of the concrete and thus an ideal water cement ratio can be achieved.
- The surface hardness of the slab increases by 130%.
- Water absorption is reduced enormously.
- Minimum dusts.
- Minimized crack formation.
- Shrinkage reduced by 50%.
- Improved wear resistance.
- More durable.
- High and early strength, minimize damage to newly cast floors.
- Void-free & Denser concrete.

VI. LIMITATIONS OF VDCC

- High initial cost.
- Need trained labor for the vacuum dewatering process.
- Need specific equipment for vacuum dewatering like vacuum pump.
- Need power consumption during dewatering process.

VII. SUCCESS STORY

This technique is widely used in all Scandinavian countries and is now being implemented in Hyderabad by Great Hyderabad municipal corporation(GHMC). Initially vacuum dewatered cement concrete road was constructed for 230meters as a pilot study with a total budget of around 34 lakh Indian rupees. After obtaining satisfying results the GHMC is working on 78-80km distance with the cost of 7784 crore rupees. It also has the catch pits for storm water collection system. Figure 10 and 11 shows the pictures of this method being implemented in Hyderabad.

Other than roads, this method can also be implemented in civil engineering constructions like, concrete roads, bridges and harbors; industrial floorings, manufacturing areas; cooling towers; pharmaceutical companies; Hydropower plants; warehouses, store houses, factories; sports courts; parking areas and can also be used as base floors for special finish floorings like epoxy floorings. Figure 12 shows the successful implementation of VDCC method for flooring application in a building.

Fig.10- VDCC road construction at Hyderabad; source weblink-

Fig.11- Hyderabad VDCC road working; source weblink -

VIII. CONCLUSION

From the above review and success stories it can be concluded that,

- Vacuum dewatering process is one of the technique that can be implemented in modern construction work due to its long lasting durability and minimum post construction maintenance cost.
- Good quality pavements and floors can be obtained.
- The compressive strength can be increased by 25-45%.
- 15-25% of extra water present in roads is extracted and further can be used for VDCC construction process.
- Can avoid the damages and prevent stagnation of water on the roads which in turn reduces the accidents due potholes.

Fig.12- VDF constructed flooring; source weblink- https://encrypted-tbn0.gstatic.com/

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