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BASALT ROCK FIBRE

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ABSTRACT

The use of basalt fibres was investigated in low cost composites for civil infrastructure applications requiring excellent mechanical properties and long lifetimes. Basalt fibres were thought to have great potential as reinforcement in both polymer materials and in concrete. However, this research focused on the use of basalt fibre in various fields.
Keywords: Fibre

I. INTRODUCTION

Basalt is well known as a rock found in virtually every country round the world. Its main use is a crushed rock in construction and in high way engineering. However, it is not commonly know that basalt is used in manufacturing and made into fine and ultrafine fibres. Comprise of single-ingredient raw materials manufactured from basalt fibres are superiors to other fibres in terms of thermal stability, heat and sound insulation properties, resistance to vibrations and durability. Basalt continuous fibres offer prospect of a completely new range of composite products and materials. Basalt have no toxic reaction with air or water, are non-combustible and explosion proof. When they come in contact with other chemicals they produce no chemical reactions that may damage health or the environment. Basalt is capable of replacing almost all applications of asbestos and has three times its heat insulating properties.

Basalt base composites are able to replace steel and known reinforced plastics (1 kg of basalt reinforces equals 9.6 kg of steel). The duration of basalt pipes, designed for variety of applications is at least 50 years without maintenance or electric or technical protection. Basalt fibres together with carbon or ceramic fibres as well as various metals is the most advanced and exiting area of application, as they can develop new hybrid composite materials and technologies. Basalt has unique properties that reduce the cost of products whist improving their performance. More than hundreds specific unique manufacturing techniques using basalt FIBRE materials and products have been developed and patented in Russia. The specific gravity of this material is nearly 3 and it can be extremely hard, ranging from 5 to 9 on the Mohr's' scale. As a result of this hardness, its abrasion resistance is very good and is often used in its natural form as a paving and building stone.

History:

The first with the idea to extrude fibres from basalt is of Paul Dhe from Paris, France. A U.S. patent was granted to him in 1923.Around 1960; both the U.S. and the former Soviet Union (USSR) began to investigate basalt FIBRE applications, particularly in military hardware, such as missiles. In the northwestern U.S., where large basalt formations are concentrated, Prof. R.V. Subramanian of Washington State University (Pullman, Wash.) conducted research that correlated the chemical composition of this fibre with the conditions for extrudability and physio-chemical characteristics of the resulting FIBRE. Owens Corning and several other glass companies conducted independent research programs, which resulted in several U.S. patents. Around 1970, however, U.S. glass companies abandoned basalt fibre research for strategies that favored their core product. The result was a better glass FIBRE including successful development of S-2 glass FIBRE by Owens Corning. During the same period, research in Eastern Europe, which had been carried out in the 1950s by independent groups in Moscow, Prague and other locales, was nationalized by the USSR's Defense Ministry and concentrated in Kyiv, Ukraine, where technology wwa subsequently developed in closed institutes and factories. After the breakup of the Soviet Union in 1991, the results of Soviet research were declassified and made available for civilian applications.

***Current position*:**

Today, basalt FIBRE research, production and most marketing efforts are based in countries once aligned with the Soviet block. Companies currently involved in production and marketing include Kamenny Vek (Dubna, Russia), Technobasalt (Kyiv, Ukraine), Hengdian Group (Shanghai) & Gold Basalt Fibre Co. (Shanghai, China), and OJSC Research Institute Glass plastics and FIBRE (Buchan, Ukraine). Basaltex, a division of Masureel Holding

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(Wevelgem, Belgium), and Sudaglass FIBRE Technology Inc. (Houston, Texas) convert basalt FIBRE into woven and nonwoven reinforcement forms for the European and North American markets, respectively.

II. MANUFACTURING PROCESS

The production of basalt FIBREs is similar to the production of glass FIBREs. Basalt is quarried, crushed and washed and then melted at 1500° C (Ross, A., 2006). The molten rock is then extruded through small nozzles to produce continuous filaments of basalt FIBRE. The basalt FIBREs do not contain any other additives in a single producing process, which gives additional advantage in cost. It is known that basalt FIBREs have better tensile strength than Eglass FIBREs, greater failure strain than carbon FIBREs as well as good resistance to chemical attack, impact load and fire with less poisonous fumes.

Manufacturer of basalt FIBREs (e.g. Kamenny Vek in Russia) say that basalt FIBREs have preferable mechanical properties, such as higher tensile strength, as well as a lower manufacturing cost than glass FIBREs (Kamenny Vek, 2009). Kamenny Vek also says recycling of basalt FIBREs is much more efficient than glass FIBREs and therefore basalt FIBREs can be environmentally friendly (Kamenny Vek, 2009). Basalt FIBRE can be classified as a sustainable material because basalt FIBREs are made of natural material and when the basalt FIBREs in resin are recycled the same material is obtained again as natural basalt powder (Kamenny Vek, 2009).

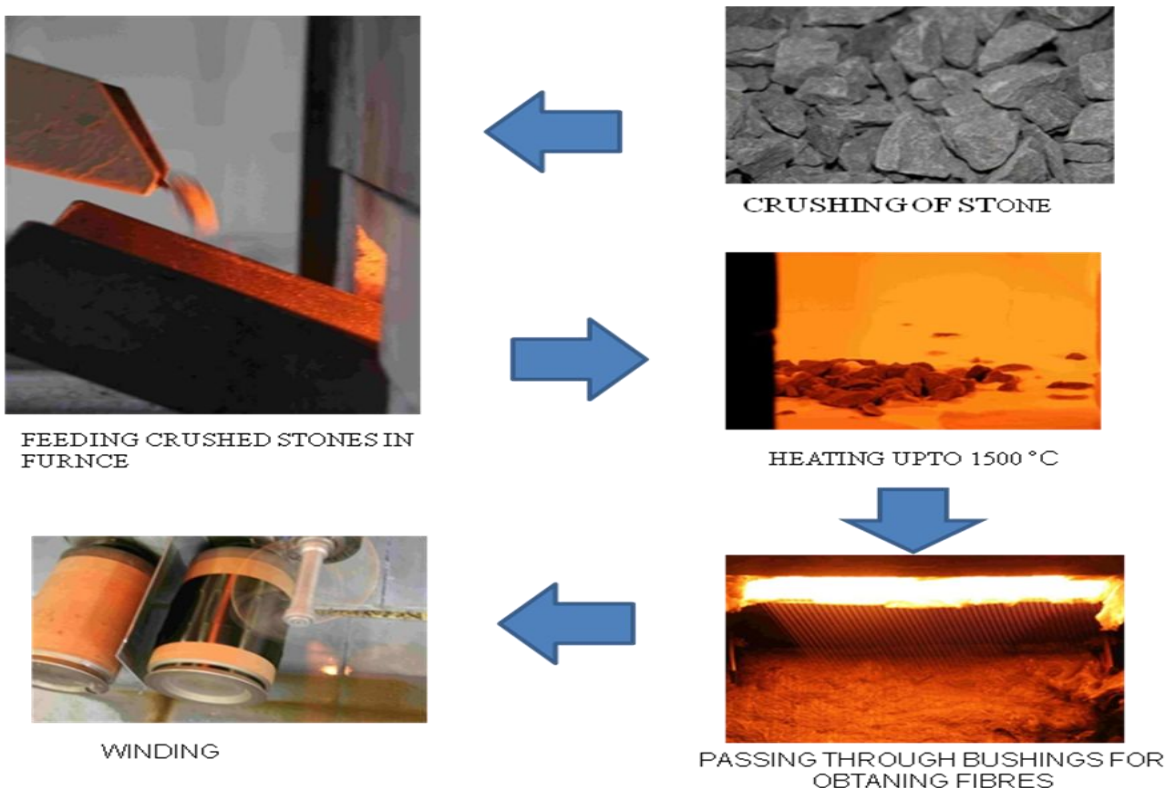

Fig. 1: Showing Manufacturing Process of Basalt

III. BASALT FIBRE PRODUCTS

Following are basalt fibre products:

1) Basalt chopped fibres
2) Basalt fabric
3) Basalt fibre
4) Basalt mesh
5) Continuous basalt fibre
6) Basalt plastic pipe

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1)Basalt chopped fibres

Basalt Chopped FIBREs can be mixed directly into polymers and concrete to increase tensile strength and reduce cracking and chipping.

- Basalt chopped FIBREs are available from 13 micronsto 19 microns in diameter
- Basalt chopped FIBRE lengths available from 3mm to130mm
- Resistant to alkali in concrete and require no specialcoatings
- Basalt chopped FIBREs resist cold down to -260°Fand heat up to 1,500°F
- Do not conduct electricity or induce electrical fields
- Basalt chopped FIBREs do NOT absorb or wick water.

Basalt fibres unlike other fibres will not harbor bacteria or microbial growth. Corrosion is caused in municipal sewers by aerobic bacteria. These convert into sulfuric acids which quickly dissolve concrete.Basalt FIBREs will not harbor these bacteria. Due to basalt's low thermal conductivity, deposition of salts and paraffin's inside the pipes is also reduced. Structural basalt composite components (such as pipes and rods) are made from unidirectional basalt reinforcement. In combination with its high specific strength (9.6 times as high as steel), high resistance to aggressive media, and high electrical insulting properties, this results in specialty products such as insulators for high voltage power lines. For asphalt fully over one half inch less thickness can be laid down saving tons of asphalt while gaining a 30-50% better lifespan!

Basalt composite pipes can transport corrosive liquids and gases. So, thinner panels with less cracking and the ability to maintain fine molded details without small areas chipping off or breaking.

2)Basalt fabric

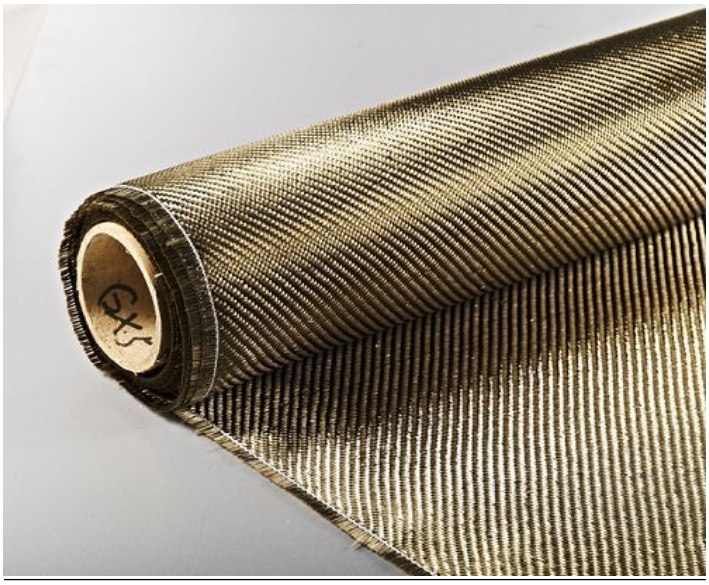

Fig2.Basalt fabric

Basalt Fabrics are yarns manufactured to varying thickness, weight, weave pattern and weavingtechnique according to end-use requirements.

- Good adhesion characteristics for coatings
- Non-combustible land fire-resistant
- Excellent tensile strength
- Maintains integrity at temperatures up to 600°C
- Resistant to electromagnetic radiation
- Basalt Fabrics for high-performance applications from construction to clothing:
- Fire curtains for fire protection and containment(Tested and certified to BS 476)
- Wall laminate to enhance burn-through times to meet building codes and regulations
- Filtration material for industrial emission stacks and
- bag-houses

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- Roof protection from fire devastation
- Fireproof clothing
- Reinforcement in composites
- Electromagnetic shields

3)Basalt fibres

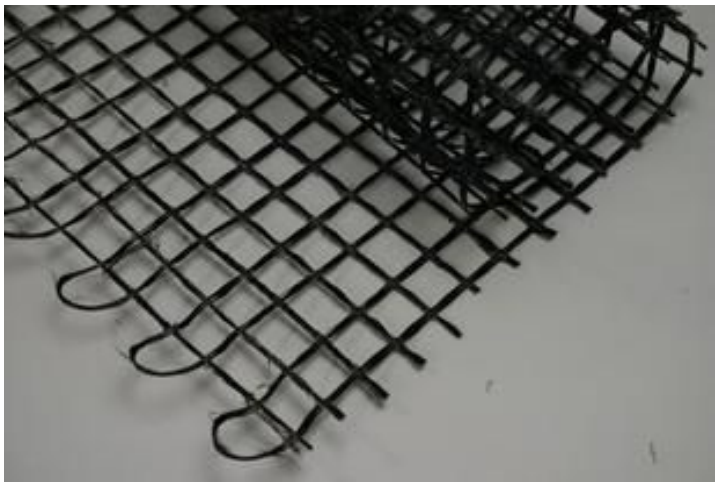

Fig 3. Basalt fibre

It is able to withstand temperatures up to 1800F/982°C,basalt mat/felt is made of 100% continuous-filamentbasalt FIBRE manufactured in thicknesses to suit abroad range of applications as follows:

- Engine exhaust systems
- Hot section heat shields
- Industrial and domestic furnaces
- Turbines
- A safe asbestos replacement
- High sound absorption for noise abatement
- Fire protection/containment in refineries and oil rigsRefrigeration insulation Basalt mat/felt provides veryLow thermal conductivity and can withstand continuous working temperatures in excess of 1500F/816C, making it a flexible material that ensures exceptional high-temperature performance With excellent drape ability, basalt conforms to irregular surfaces to meet a variety of design needs, while its chemical properties make it highly durable and safe.
- Non-respirable, 13 micron filament diameter
- Meets chemical acceptability of NRC Guide 1.36,section C
- Very high alkali and acid resistance (surpassingmost mineral and syntheticFIBREs)
- Negligible moisture absorption (less than 1% at 65%relative airhumidity)environmental
- Remarkable immunity to nuclear radiation, UV lightand biologic contamination.

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4)Basalt mesh

Fig 4.Basalt mesh

Strengthen concrete with rebar mesh. Available in different sizes with epoxy coatings for concrete and composites and asphalt coatings for asphalt reinforcement. Basalt Mesh is better than steel for many reasons

- Stronger than steel wire of comparable size
- By far lighter and easier to handle and install (nonasty cuts).
- Will not rust or corrode or cause cracking ofconcrete
- Flexible for easier design
- Basalt does not conduct electricity or induce electricfields
- Basalt Mesh binds well with both asphalt andconcrete
- Many mesh sizes available: 5x5mm, 10x10mm,25x25mm and 50x50mm Coated or uncoated meshAvailable.
- It is used for reinforcing asphalt-concrete (covering in construction, reconstruction and repair of airport, runways, highways and any pavements, pedestrian ways, road inclines and banks).
- The reinforcement with basalt mesh and Geo-grid increases the overall reliability, safety and the cutting process output. The strength of basalt mesh is asgood as metal reinforcement, however it is also 2.6 times lighter, thereby simplifying transportation and handling in construction.
- Basalt Geo-grid is more durable than metallic and glass-FIBRE reinforcement due to basalt FIBRE ' s excellent performance. Like all the basalt articles it is an ecologically safe material. Basalt reinforcing mesh makes it possible to reduce thickness of asphalt concrete pavement up to 20%.

5)Continuous basalt fibre

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Fig 5. Continuous basalt fibre

- BCF possesses some advantages over glass FIBRE,including its strength,
- chemical stability and temperature of application;
- Wide availability and low cost of basalt, which is an initial raw material
- for BCF production;
- Production is carried out with application of one- phase technology;
- Development of technology and equipment for BCFproduction during

5) Continuous basalt fibre:

Fig6.Basalt-plastic pipe

Basalt fibre composite pipes are obtained by winding basalt threads, fabrics, prepegs impregnated with a binder. The pipes may be useful as components for shafts linings, building components, for transporting corrosive liquids and gases in the construction, industrial, agricultural and public services sectors. Other possible areas of application for basalt pipes are: masts, aerials frame various pipes in construction, communication, etc. At present when the price difference between metal and composite pipes is becoming smaller and in view in substantial advantages of the composite pipes, the use of repair old pipelines and construction of new ones is growing dramatically.

- The weight of one meter of basalt-plastic pipes is 3 to 4 times less than the one of steel pipe. This is not only simplifies handling operations, but also essentially reduces cost for transporting load-lifting and installation work.

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- The strength of a plastic-plastic pipe is several times stronger than that of glass-fibre pipes and of the majority of steel-pipes. This quality of basalt-plastic makes it possible to create high pressure systems of higher reliability, i.e. over 1000 atm, which is not practically with metal pipes.
- High chemical resistance to aggressive media makes it possible to manufacture pipelines for transporting hydrogen sulphide, acid alkalis etc.
- And as a result of the above, there is no need for insulation and anti corrosion measures.
- Basalt pipes are resistant to the action of fungi and micro organisms
- Basalt-plastic has low thermal conductivity, thereby preventing the depositionof salts and paraffin ' s in pipelines and requiring no additional heat insulation.
- Being insulators, basalt-plastic pipes are resistant to electrochemical corrosion. All this makes it possible to increase the guaranteed service life of basalt-plasticpipes to 60 – 80 years, i.e. 2 to 3 times as that of metallic ones.
- The equipment intended for producing of fibreglass plastic pipes can be adapted to manufacture pipes of various diameters and wall thickness.

IV. USES

- Heat protection
- High pressure vessels (e.g. tanks and gas, cylinders)
- Load bearing profiles
- Windmill blades
- Lamp posts
- Ship hulls
- Car bodies
- Sports equipment
- Concrete reinforcement
- Speaker cones
- Cavity wall ties
- Thermal and sound insulation,
- Pipes for various, purposes.
- Bars, fittings.
- Fabrics nets, prepregs.
- Structural plastics, Insulating plastics.
- Frictional materials

V. APPLICATIONS

General:

- Crushed stone, concrete aggregate, railroad ballast, production of high quality textile FIBREs, floor tiles, acid-resistant equipment for heavy industrial use, rockwool, basalt plastic pipers, basalt plastic reinforcement bars, basalt FIBRE roofing felt (ruberoid), basalt laminate used as a protective coating, heat-insulating basalt FIBRE materials, glass wool (FIBRE glass), etc.
- Basalt is the best reinforcement for concrete due to its tensile strength and natural resistance to deterioration from alkali
- Reinforcement for composites, polyester/epoxy resins and plastics as used in automotive body panels, boat hulls and pultruded products, etc.
- Friction materials such as brake pads and linings.
- Manufacture of basalt mat/felt.
- High-temperature insulation applications.
- Passive fire protection materials.
- Filler for gypsum and sheetrock board requiring increased 'burn-thru' capability, to meet building regulations
- High-performance automotive muffler filler.

Construction:

- Reinforcement of bridges, tunnels.
- Production of sandwich-panels based on basalt and carbon-basalt FIBREs.
- External and internal heat and soundinsulation.
- Insulation of panel butt joints.
- Directional and dispersive reinforcementof concrete.
- Repair (healing) of cracks, local damage to buildings, bridges,buildingconstructions.
- Soft roofing (of slate and tile type).

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- Reusable shutters.
- Internal waste pipes.
- Reinforced structures
- Heat-supply systems, cable conduits.
- Hydraulic construction

Road Construction:

- Reinforcement of concrete and asphalt
- Pavements runways.
- Construction of sound-absorbing barriers
- For highways, railways, and underground
- Metro lines.
- Curb stones, pavement linings (basaltcasting).
- Small moulds.

Engineering networls:

- Pipelines for heating and hot water supply.
- Pipelines for heat supply.
- Canalization.
- Oil and gas pipelines.
- Cable-conduit, telephone systems protected against electromagnetic fields and
- Information leakage through electronic surveillance.
- Highly efficient seals and linings for pipelines.
- Pipes for chemicals production and transportation of aggressive media.
- Pumps for aggressive media

Agriculture:

- Land drainage pipes.
- Pipes for irrigation and hosing.
- Raising vegetables and seedlings (hydroponics) (Basalt superthin FIBREs).
- Agricultural construction.
- Agricultural machine construction.

Underground Construction:

- Anchors, pillars, ceilings, vaults.
- Pipelines for various purposes.
- Foundations for buildings and constructions. Trenches laying of pipelines.

Nuclear power engineering:

Basalt materials do not absorb the radioactive radiations, which makes them to consider as the potential material in production and transformation of radioactive materials, in nuclear power plants. Protective cap using geo-composites in the waste disposal sites, incorporating basalt materials, can offer the best protection for the human health and environment against the radioactive wastes.

Concrete reinforcements:

Requirements of the moderate strengthening in the civil structures and high fire resistance can be met with basalt FIBREs while FRP strengthening can be considered for pure strengthening. Applicability of basalt FIBREs as a strengthening for concrete structural materials has been studied for durability, mechanical properties and flexural strength. Basalt filaments incorporated unidirectional rods are used as the reinforcement of concrete slabs in hydraulic engineering and construction in seismically hazardous regions. There are two methods, wet and dry, for production of basalt cloth that allows one to prepare cloth of different types. Basalt FIBREs in a basalt cloth form a regular pattern in which they are cross-linked by means of organic additives, mostly thermo reactive resins. The basalt cloth is a porous material which allows easy impregnation; furthermore, it exhibits a high chemical stability and sealing, anticorrosion and fire-proof properties, and finds multiple uses in the production of insulating materials, in the automotive industry, civil engineering, etc. The basalt cloth can also be used as a reinforcing material, as stabilizing or separating layers, as a material for surface finish, or for sound insulation. For floating concrete pontoons, steel is used, with time salt water is penetrating into concrete and will come into contact with the steel

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reinforcement causing to rust and crack to the concrete. Designing of new reinforcement which is a non-corrosive, nonmagnetic and non-electric leading material and has a longer life can replace the steel reinforcement.

VI. BASALT REBAR

Basalt rebar is an alternative to steel and FIBR, E glass for reinforcing concrete Made from volcanic rock basalt rebar is tough, stronger than steel and has a higher tensile strength. Much lighter than steel, 89% percent in fact! One man can easily lift a 500foot coil of 10 mm basalt rebar. Basalt rebar is naturally resistant to alkali, rust andacids .Moisture penetration from concrete does not spall. Needs no special coating like fibre glass rods. Basalt rebar has the same thermal coefficient expansion as concrete! Allowing thinner, lighter panels and decks, basalt rebar reduces the thickness and spacing between the rods and the concrete and surface. Much more flexible design! Smaller rods allow for more critical spacing and designs. Basalt rebar is easily cut to length with regular tools. Basalt rebar does not conduct electricity or induce fields when exposed to RF energy, great for MRI or databuildings. Basalt rebar is perfect for Marine environments and Chemical plants where corrosion is a continuous concern. Basalt composite bars are made by utilizing basalt FIBREs and a resin epoxy binder. They are non-corrosive, consist of 80% FIBREs and have a tensile strength three times that of the steel bar normally used in building construction. Wherever corrosion problems exist, basalt FIBRE composite bars have the potential to replace steel in reinforced concrete. Currently there are many FRP bar manufacturing companies which market their products. Most of these bars are made of E-glass FIBRE and thermosetting resin. However FRP bars lack sufficient durability under extreme conditions. These bars are costly and are also non-resistant to alkalis. Basalt bars do not possess these disadvantages and can be effectively used in various applications such as highway barriers, offshore structures, and bridge decks. The above mentioned advantages alone could warrant a sufficient argument for substitution of steel bars with basalt bars on a large scale. Other advantages of the basalt bar are that its weight is one-third of the weight of steel and the thermal expansion coefficient is very close to that of concrete. The high mechanical performance/price ratio of basalt FIBRE composite bar, combined with corrosion resistance to alkaline attack, are further reasons for replacing steel in concrete with basalt FIBRE composite bars. Rods of unidirectional basalt composite successfully replace metal reinforcement. At higher specific strength and resistance to aggressive media 1 kg of the basalt reinforcement replaces 9.6 kg of metallic. They are used in production of building components, panels' barriers sidewalk, pavement and facing slabs, and many other structural components. In view of their high electro insulation properties, basalt bars are used for making insulators for high voltage power lines. An especially successful application of bars is for reinforcement of concrete slabs in hydraulic engineering and construction in seismically hazardous regions, in view of the fact that due to its chemical inertness the basalt reinforcement is compatible with concretes having different "pH", having actually the same coefficient of thermal expansion and no residual deformation under bending.

VII. ADVANTAGES& LIMITATIONS

Advantages

- High tensile strength
- Alkali resistant
- High thermal conductivity
- No carcinogenic risk or other health hazards
- Completely inert with no environmental risks
- Resistant to acids and aggressive chemicals
- High E modulus resulting in excellent specific tenacity, three times that of steel FIBRE
- Good fatigue resistance
- Electro-magnetic resistant
- Higher mechanical strength and modulus,
- More resistive to chemical aggressive environment than E-glass mesh.
- Lower cost and better mechanical properties than for mesh made of special glass FIBRE.
- The melting point of basalt FIBREs is 1450°C.
- Lower elongation before brake than for synthetic material.
- Easily milled using typical milling equipment. Does not stretch and pull as polymer meshes.
- No special equipment is required to install then reinforcement.

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- Basalt mesh is environment friendly and based on naturally occurring material that is found worldwide
- Higher specific strength
- Resistant to corrosion
- Coefficient of thermal expansion is nearly same as that of concrete.
- No permanent deformation when bent
- Chemically inert

***Limitations*:**

- Technology is not so developed to prove economical.
- Initial investment is high.

VIII. CONCLUSION

After having thorough study over this upcoming environment friendly material, it is seen that basalt base composites can replace steel and known reinforced plastics (1 kg of basalt reinforces equals 9.6 kg of steel). Also it is having wide scope in different industries such as, Rebar, fabric, geo synthetics, pipes, nuclear power plant, bridge construction, underwater construction etc..At present cost of this material is little higher than the steel but The effective utilization of the material can be proven as a step towards reducing the pollution caused due to material such as steel, plastic; as this material can be said as chemically inert.

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