Basalt bars and basalt mats for use in concrete structures.

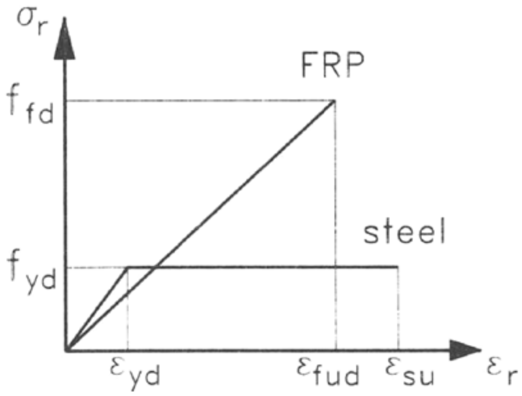
Research program is ongoing at SEL to test basalt bars and basalt mats (BFRP) for strengthen concrete structures. The research are done in collaboration with Icelandic Innovate Center and financed from The Technology Development Fund, RANNIS.

The need for non-corrosive reinforcement of the construction industry has developed in the last decades. There have been several researches and tests of integrating basalt fibers into concrete structures, mainly concrete beams. The tests have shown improvements in strength and durability. In this review paper the focus is on the basalt fiber bars, the possible usage of such bars instead of the common steel reinforcement rebar. One of the benefits of using Fiber Reinforced Polymer (FRP) as a strengthening material in concrete is that it is non-corrosive. In places where concrete structures are close to the sea, like houses or bridges, the maintenance of the concrete is needed on regular basis. In such conditions the common rebar is in constant danger of corrosion and therefore could become weak and hazardous in a short period of time.

Basalt rock can be used to make not only basalt bars but also basalt fabrics, chopped basalt fiber strands, continuous basalt filament wires and basalt mesh. Some of the potential applications of these basalt composites are: plastic polymer reinforcement, soil strengthening, bridges and highways, industrial floors, heat and sound insulation for residential and industrial buildings, bullet proof vests and retrofitting and rehabilitation of structures.

Basalt fiber is a material made from extremely fine fibers of basalt. The manufacture of the basalt fiber is by melting the quarried basalt rock. The molten rock is then extruded through small nozzles to produce continuous filaments of basalt fiber. The basalt fibers do not contain any other additives in a single producing process, which gives additional advantage in cost. It is known that basalt fibers have better tensile strength than E-glass fibers, greater failure strain than carbon fibers as well as good resistance to chemical attack, impact load and fire with less poisonous fumes.

FRP composite consists of matrix material, such as epoxy, that is reinforced with fibres. The epoxy binds the fibres together and transfer stresses to the fibres by adhesion and protects them from environmental damage [16]. These fibres are indefinitely long and are generally mentioned as continuous fibres.



Stress strain model of FRP compared to steel

Compared to steel, fibres do not exhibit yielding during tension but instead the stress strain model of FRP materials is modelled as linear elastic to failure. Failure initiates when the fibres reach their ultimate strain. It is assumed that all fibres in a composite fail at the same time in theoretical models, however in reality fibres rupture at various strain levels. Some regions of the cross-section become weaker as the number of fibres ruptures which causes the failure of the composite along that region. If the fibre volume in a composite is not sufficient, the matrix cannot support the entire load when the fibres rupture and composite failure will then take place instantly.

FRP composite in Civil Engineering

The use of FRP composite in civil engineering can be categorized into two types. The former type is strengthening where the original structure´s strength is enhanced because of change of function in the structure or to make the structure capable of resisting possible earthquakes which most recent structures are designed for because of more stringent design codes. Repair is another type where existing structures are repaired to bring back the load capacity which it was designed for. The necessity for repairing can be caused by environmental deterioration or by damage in service. These two types are known as retrofitting applications. This technique has been successfully used for flexural strengthening in beams and slabs, shear strengthening of beams and for axial strengthening and ductility enhancement of columns.

In column retrofitting the FRP make an external jacket which provides confinement to the column. This confinement can be either active or passive and the confinement is achieved where the confining pressure is engaged by transverse dilation of the column under compression. This technique has many advantages over steel which has been used for strengthening since in the 1960s. Some of the advantages are:

- FRP composite materials have higher ultimate strength and lower density than steel, so the strength to weight ratio is higher for FRP composites.
- Higher corrosion resistance.
- Lighter unit weight which makes handling and installation easier than steel which leads to less expensive equipment needed for application.
- Faster field installation and no risk of damaging the existing reinforcement because of no mechanical anchors.
- Capability of following curved lines of the structure in retrofitting.

However the use of FRP composite has some limitations such as uncertainties about the durability in long term performance, risk of fire and accidental damage unless the composite is protected.

FRP System

The most widely used method in structural engineering for applying FRP composite to structural elements is the hand layup process. Fibre sheet is impregnated with epoxy resin using handheld rollers which is the pressed on the concrete surface to form the FRP composite and is cured at ambient temperature. The fabrication procedure starts by applying a layer of resin on the concrete surface with rollers and then the dry sheet is placed on the surface. Rollers are then used to depress the sheet into the resin and an overcoat of resin layer is applied to finish the impregnation. If an additional layer is required the process is repeated. A finishing layer can then be provided such as painting for better appearance.