Industry is always striving to find new and better materials to manufacture new or improved products. With this in mind energy conservation, the environment, corrosion risk and sustainability are important factors when a product is changed or a new product is manufactured. A few examples of problem overviews that relate to some of these important factors are explained below. High voltage towers have, almost from the beginning, been designed as steel truss towers and in the next few years will need to be replaced. Therefore there is now the opportunity design a new type of tower made of a new material that is strong, light and has minimum risk of corrosion. A large part of lampposts and telephone poles have also been designed as steel and wood for years and there is also a need for new materials which are strong, light and with a minimum risk of corrosion. Structural designers, as for buildings, bridges and windmills, are always looking for new solutions for better and/or bigger structures. One of the solutions could be a new material which is also strong, light and with minimum risk of corrosion. Aircraft, ships and the automobile industries are always trying to develop lighter units without losing material strength to make energy conservation. In this sense the energy required for the production of basalt fiber is around 5 KWh/kg while for carbon steel product is about 15 KWh/kg.

This introduction focuses on Fiber Reinforced Polymers or FRP where the polymer-based resin is the matrix with a variety of fibers. Figure 1 illustrates how the properties for the composite material FRP can be combined with the properties from the resin and the fiber.

![Figure 1. Properties of FRP combined with the properties from the resin and fibre (SP Systems, n.d.).](image_url)
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 (Ramakrishnan, V. & Panchalan, R., 2005).

At Structural and Composite Laboratory at Reykjavik University (www.sel.ru.is) have been ongoing several researches about strengthening concrete beams and columns by basalt FRP materials in past years. These tests have shown improvements in strength and durability compared to unstrengthen concrete members.

**Properties of Basalt**

Basalt is fine-grained, extrusive, igneous rock composed of plagioclase, feldspar, pyroxene and magnetite, with or without olivine and containing not more than 53 wt% SiO₂ and less than 5 wt% total alkalis. Many types of basalt contain phenocrysts of olivine, clinopyroxene (augite) and plagioclase feldspar. Basalt is divided into two main types, alkali basalt and tholeiites. They have a similar concentration of SiO₂, but alkali basalts have higher content of Na₂O and K₂O than tholeiites. The plutonic equivalent of basalt is gabbro.

**Basalt fiber fabrication**

The production of basalt fibers is similar to the production of glass fibers. 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 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 (Sim, J., C., & Moon, D. Y., 2005).
Manufacturer of basalt fibers (e.g. Kamenny Vek in Russia) say that basalt fibers have preferable mechanical properties, such as higher tensile strength, as well as a lower manufacturing cost than glass fibers (Kamenny Vek, 2009). Kamenny Vek also says recycling of basalt fibers is much more efficient than glass fibers and therefore basalt fibers can be environmentally friendly (Kamenny Vek, 2009). Basalt fiber can be classified as a sustainable material because basalt fibers are made of natural material and when the basalt fibers in resin are recycled the same material is obtained again as natural basalt powder (Kamenny Vek, 2009)

**Basalt fiber bar**

Basalt composite bars are made by utilizing basalt fibers and a resin epoxy binder. They are non-corrosive, consist of 80% fibers and have a tensile strength three times that of the steel bar normally used in building construction. Wherever corrosion problems exist, basalt fiber 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 fiber 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 fiber composite bar, combined with corrosion resistance to alkaline attack, are further reasons for replacing steel in concrete with basalt fiber composite bars.

**Continuous Basalt Fiber as Reinforcement Material in Polyester Resin**

Composite materials are composed of two or more elements working together to produce material properties for one composite material (physical, not chemical). The composite material generally consists of a matrix and some type of reinforcement. The reinforcement is usually used in fiber form (for example carbon or glass fibers) and used to increase the strength and stiffness of the matrix (for example epoxy or polyester resins) (SP Systems, n.d.).
Fiber reinforcements in composite material are generally used to improve the mechanical properties in an undiluted resin system. The most common fiber reinforcement in resin is glass fiber, accounting for up to 99% of world production (Árnason, P., 2007, p. 143). There are other types of fibers for reinforcement such as carbon fiber, other plastic fibers and the newest, basalt fiber.

**North Atlantic Igneous Province**

Earth history is marked by events when large volumes of mainly basaltic magmas were generated and emplaced in geologically short periods of time, by processes unrelated to the “normal” sea-floor spreading and subduction. The term “Large Igneous Province” (LIP) was first introduced by Mike Coffin and Olaf Eldholm in 1991, to describe large igneous formations (Bryan and Ferrari, 2013). LIP are best preserved in the Mesozoic and Cenozoic formations where they occur as continental flood basalts, volcanic rifted margins, (aseismic) submarine ridges, giant oceanic plateaus, seamount groups and flood basalts in oceanic basins (Coffin & Eldholm, 1992; Saunders, 2005). Many or even all the LIP’s are connected to a hotspot, a stationary region where hot plumes of material are upwelling from the mantle of earth (Sobolev et al. 2011). The energy of the plume causes partial melting of the uppermost parts of the mantle and the crust, and provides the quantities of magma needed for the eruptions. Many LIP’s can be linked to regional-scale uplift and continental rifting and breakup, e.g. North Atlantic Igneous Province (NAIP) (Saunders et al. 1997).

Many oceanic submarine ridges follow emplacement of continental flood basalt province or oceanic plateaus in time (Coffin & Eldholm, 1992). A prime example is the Faroe-Iceland-Greenland Ridge of the North Atlantic Volcanic Province. Volcanism associated with the continental rift and break-up of NW Europe and Greenland during the Late Paleocene to Early Eocene influenced a broad area along of the forming North Atlantic, but subsided shortly after the seafloor spreading of the North Atlantic commenced. The Iceland region on the other hand continues vigorously to build up by magmatic activity since the Late Oligocene.

The NAIP is made up of both onshore and offshorebasalt floods, sills, dykes, and plateaus. The NAIP was split in two by the opening of the North Atlantic and its principal components are now widely distributed and exposed in East and West Greenland, on the Faeroe Islands and in the British Isles (Saunders et al. 1997). Most of the British Tertiary igneous province (BTIP), crops out in Antrim (Northern Ireland) and on the Isles of Mull and Skye in Scotland (Fig. 1) (Saunders et al. 1997). The province includes flood basalts that were erupted along
volcanic passive margins (e.g. Greenland, Norway) during continental breakup (Fig. 2). But the main formation of the NAIP is the volcanism that can be associated with anomalous volcanism for 56–61 Ma in the form of aseismic ridges that stretch across the North Atlantic Ocean through Iceland, i.e. the Greenland-Iceland-Ridge and the Faeroe-Iceland-Ridge (Bjarnason, 2008). With Iceland forming the prominent area of the NAIP that was and is built by the interaction between the Iceland Plume (hotspot) and the Mid-Atlantic Ridge (Saunders et al. 2005).

Basalt flows cover about 70% of the earth’s surface and the largest formation of the NAIP is the North Atlantic ocean crust that is made up of the mid ocean ridge basalts from the Reykjanes, Kolbeinsey and Mohns active spreading ridges.

Figure 2. Geological map of the Northeast Atlantic region showing the distribution of NAIP, e.g. continental flood basalt, volcanics mapped seismically as seaward-dipping reflectors, and thick oceanic crust of the Greenland–Iceland–Faroes Ridge (Tegner et al. 2006).
References:


