A multi-purpose reusable form for columns of all shapes and sizes

Forming new columns is a challenging task in construction. This article describes a recently developed product that can overcome many of the shortcomings.

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Disposable one-size cardboard tubes are very bulky for storage and transportation, and after each use must be torn and sent to landfill. Other forms that are made with wood or metal panels and frames, and are modular, are also used commonly. As these panels offer virtually no resistance to the lateral pressure of the freshly cast concrete, the segments must be tied externally with bolts, clamps and the like. These forms can become very heavy and add significant time and expense to the project. Handling these forms in areas with limited access for lifting equipment, such as on the upper floors of a building, introduces another level of complexity.

The problem becomes even more severe when an existing column needs to be repaired or strengthened by enlargement. This happens frequently in structures that are prone to corrosion, such as bridges, parking garages, mines, ports and piers. Seismic upgrades of older buildings or post-earthquake repairs also frequently call for enlargement of columns. In such cases, the presence of floors above means it is not possible to slip a form over the column, further limiting the contractor's options.

Figure 1: Application as reusable form.

FRP laminate form

The new product is made of high-strength fibre-reinforced polymer (FRP). Using special equipment, glass fibres are impregnated with vinyl ester resin and subjected to heat and pressure to make very thin laminates. These laminates are patented and are offered under the trade name MoTubes[1], referred to as FRP laminate form (FLF) in this article. The laminates have a uniform thickness that varies from 1 to 2mm depending on the product style.

FLF is manufactured in rolls up to 3.2m wide. A typical roll is 150m long (Figure 1a). The laminates weigh between 1.5 and 2.5kg/m^2. This light weight allows for easy handling. The unique design of FLF provides a perfect balance between a smooth-finish surface and enough friction to prevent sliding of the surfaces. The tensile strength of the laminate ranges from 80 to 230MPa.

Installation as a reusable form

The behaviour of FLF is based on principles of belt friction[1]. A piece of laminate two to three times the perimeter of the column is cut from the roll (Figure 1b) and coiled to the desired diameter (Figure 1c). A few pieces of string can be tied around the tube (Figure 1d) to maintain the size. Note that these strings are not required to resist any loads from the internal pressure of the concrete. The concrete can be placed with a hose using the tremie method (Figure 1d) or pumped. After the concrete hardens, the laminate is removed (Figure 1e), washed and cleaned (Figure 1f), and saved for future use (Figure 1g) to cast columns of the same or different sizes. Note that the finished surface of the cast concrete is very smooth (Figure 1g) and free from unsightly spiral marks that are commonly left behind when cardboard tubes are used as forms. A video of this application is available at: *https://tinyurl.com/38a9deck*.

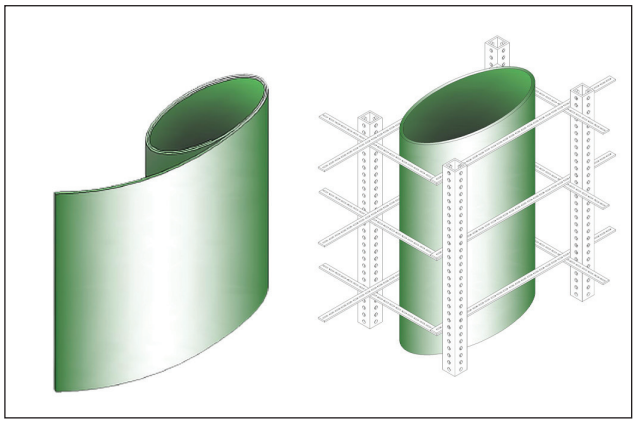

Figure 2: Creating forms of any shape or size.

Figure 2 shows how these laminates can be formed into virtually any shape. An adjustable frame may be necessary to fix the overall width and length of the column section. The only limitation is that the radius of bend at the corners of a non-circular form must be larger than the allowable limit for the laminate. This radius is a function of the thickness of the laminate and is typically approximately 50mm.

Installation for strengthening applications

Another use of the FLF is in repair and strengthening of existing columns. The procedure is shown in Figure 3, on a recent emergency repair of two columns at the University of Arizona. The columns were damaged by corrosion, and during the investigation it was determined that the concrete quality was very poor (Figure 3a). Spacers of various shapes were available through PileMedic[(2)]. These were passed through zip ties and fastened around the column (Figure 3b). Longitudinal reinforcing bars were snapped into these spacers. In this case, three 1.2m-wide laminates were cut in a length equal to twice the perimeter of the column plus 200mm. The second half of the laminate was covered with epoxy (Figure 3c) and the laminate wrapped around the column to create a two-ply thick shell (Figure 3d).

This shell was lowered into position. The spacers define the annular space created between the column and the shell. Additional 1.2m shells were similarly installed, overlapping the previous shell by 100mm. The annular space was filled with concrete using the tremie method (Figure 3e). The completed repair is shown in Figure 3f. Note that a two-ply shell provides the equivalent of 15mm-diameter steel ties at a spacing of roughly 100mm in the hoop direction. This eliminates the need for steel ties around the column, saving significant time and money. The FLF will stay permanently in place, providing protection against corrosion for the repaired column. A video of this process is available at: *https://tinyurl.com/4md85eep*.

Sustainability

The FLF presented here has several unique features that contribute to making it an environmentally friendly product. One feature is the size of the FLF. With a single roll of laminate, forms of any size can be built on-site. The other is the adjustability of the shape of the form, allowing configuration, as demonstrated in figure 2. This flexibility can add significant value to many projects. Both above features contribute greatly to reduced transportation and storage space demand, cutting down on the number of trips to the supply stores.

The light weight of FLF eliminates the need for heavy-lifting equipment on-site that may be required for bulkier steel or timber forms. FLF is also fully water resistant, making its storage easier and allowing for challenging forming of submerged columns and piles. The smooth finish of FLF leaves no unsightly marks behind and eliminates the need for grinding of the finished surface. The most significant advantage of FLF is the fact that the laminates can be used approximately 50 times, producing forms of various shapes and sizes.

Advantages

The form can be used for the repair of existing columns or to form new columns. Among the advantages are its ability for multiple uses to create forms of virtually any shape and size. FLF reduces storage space and transportation costs significantly, and is water and rain resistant, resulting in an environmentally sustainable product. ■

References:

1. EHSANI, M. *Reusable and Adjustable-Size Form for Repair and Reinforcement of Structures*. US Patent No.11,591,810, US Patent and Trademark Office, Alexandria VA, USA, 2023.
2. EHSANI, M. *Spacers for Repair of Columns and Piles*. US Patent No.10,808,412, US Patent and Trademark Office, Alexandria VA, USA, 2020.

Figure 3: Application as stay-in-place form to repair and strengthen an existing column.