Steel Pipe: More Volume, Less Cost

By Andy Kultgen

Difficult-to-access points-of-placement are common in concrete pumping and are a trademark of shotcrete. A major driving factor behind the development of concrete pumping was the requirement of placing concrete in areas that are out of reach of a ready-mix truck, and may not even be accessible by buggy or bucket. These difficult-to-access jobsites often mean that you must locate your pump far away from where you are placing the concrete, sometimes several hundred feet away. On occasion, typically in mines and tunnels or on bridges, you may need to pump thousands of feet. For many shotcrete and small-line contractors, the go-to pumping delivery line is a rubber hose. It is easy to see why—if you need a flexible line to allow the nozzleman to move around the jobsite and place the concrete around obstructions, why not just get more hoses to cover that ground between the pump and the nozzleman? However, on jobs where you need to pump longer distances or a lot of volume, steel pipeline can be a useful option to decrease the load on your pump, decrease the wear on your hoses, and provide a steady flow of concrete to your nozzleman, all at a lower cost. Those things add up to a better finished product and a better bottom line for your company.

Throughout the last several decades, concrete pumps have increased in power and maximum pressure rating, constantly raising the bar on how far concrete can be pumped. In recent years, high-performance concrete has been pumped well over a thousand feet (300 m) vertically in high-rise construction, and specialized mixtures have been pumped several miles horizontally. Those are the unique and specialized jobs, while the bulk of line concrete pumping is within several hundred feet.

It is not uncommon to explain the wet-mix shotcrete process to a layman and have them remark “You can do that?!” to several aspects of the job. They are surprised that you can pump concrete at all, and equally surprised that you can propel that concrete with compressed air onto a surface and it stays there.

When concrete is pumped, it does not behave like a liquid does when traveling down the line. Concrete moves as a relatively uniform, undisturbed ‘slug’ through the line, sliding along on a very thin film of cement, water, and fines. Studies have found that this lubricating paste layer is only about 40 mils (1 mm) thick. When this slug is moving down a straight, uniform pipe, it moves relatively easily. However, bends, reducers and any changes or breaks in the inner surface of the line can cause increased resistance to that slug of concrete moving along because the slug needs to change size or shape, aggregate is forced through the lubricating layer, or the lubricating layer is stripped away. This is the reason why a longer reducer and larger radius bends generally result in easier pumping. The concrete slug has more time to deform; that is, the aggregate rearranges, and less aggregate is forced through the lubricating layer against the pipe wall as it passes through the reducer or around a bend. Aggregate rearranging as more paste moves out to the surface of the slug is the reason you usually experience rock jams in reducers or bends, and rarely in straight sections of pipe.

This slug flow with a thin lubricating layer is the basis for the advantages of steel pipeline. A length of steel pipeline has a smooth, straight inner surface interrupted only by the joint and coupling to the next length of pipe. By comparison, the inner surface of a rubber hose can vary greatly and is not perfectly straight. The inner surface of a hose is generally rougher than a steel pipe, and there are interruptions both where the hose couples to another hose as well as where the steel hose barb starts and ends. It is because of these differences that a rubber hose is generally considered to have three to five times more resistance to pumping than an equal length of steel pipe. Additional benefits of steel pipe over rubber hose are increased wear life, ease of wear life monitoring, and lower cost.

An Example

Consider this situation to illustrate these differences between hose and pipe. A job will require 250 ft (76 m) of line between the pump and the area of placement. The concrete is a typical mixture with a 2.5 in. (64 mm) slump and you expect to pump at a rate of approximately 15 yd^3 (11 m^3)

of concrete per hour. You have a trailer pump which can exert a maximum pressure of 1100 psi (7.6 MPa) on the concrete and you have 2 in. (50 mm) diameter pumping line. Using only hose, you would have 250 ft (76 m) of hose (Fig. 1) which yields a proportional value of 750 (assuming a 3× multiplication for hose, which varies from 3 to 5× multiplication.) Using a combination of pipe and hose, you would have 200 ft (61 m) of pipe followed by 50 ft (15 m) of hose (Fig. 2) yielding a proportional value of 350. We will omit the reducers because they are the same for both cases.

Using these proportional length values, refer to the pumping nomograph (Fig. 3). Beginning with the desired pumping rate of 15 yd^3 (11 m^3) per hour, trace to the right until you hit the line for the 2 in. (50 mm) pipeline size. Then trace downward until you hit the line for your proportional length value. Trace left from that intersection to the line for 2.5 in. (64 mm) slump, and then upwards to the predicted pumping pressure.

The pumping pressure with Option 1, using only hose, will be just above 1000 psi (7 MPa), using nearly all of the pressure available from this pump, and approaching or exceeding the working pressure of many widely available pumping hoses. Adding in the resistance provided by the line reducers near the pump or any higher multiplier values from the hose based on using dirty

Option 1—Hose Only

• 250 ft (76 m) of hose

250 ft × 3 (hose multiplier) = 750 proportional ft (230 m)

Fig. 1: Proportional length calculation, Option 1

Option 2—Steel Line and Hose

• 200 ft (61 m) of steel line

• 50 ft (15 m) of hose

200 + 50 ft × 3 (hose multiplier) = 350 proportional ft (110 m)

Fig. 2: Proportional length calculation, Option 2

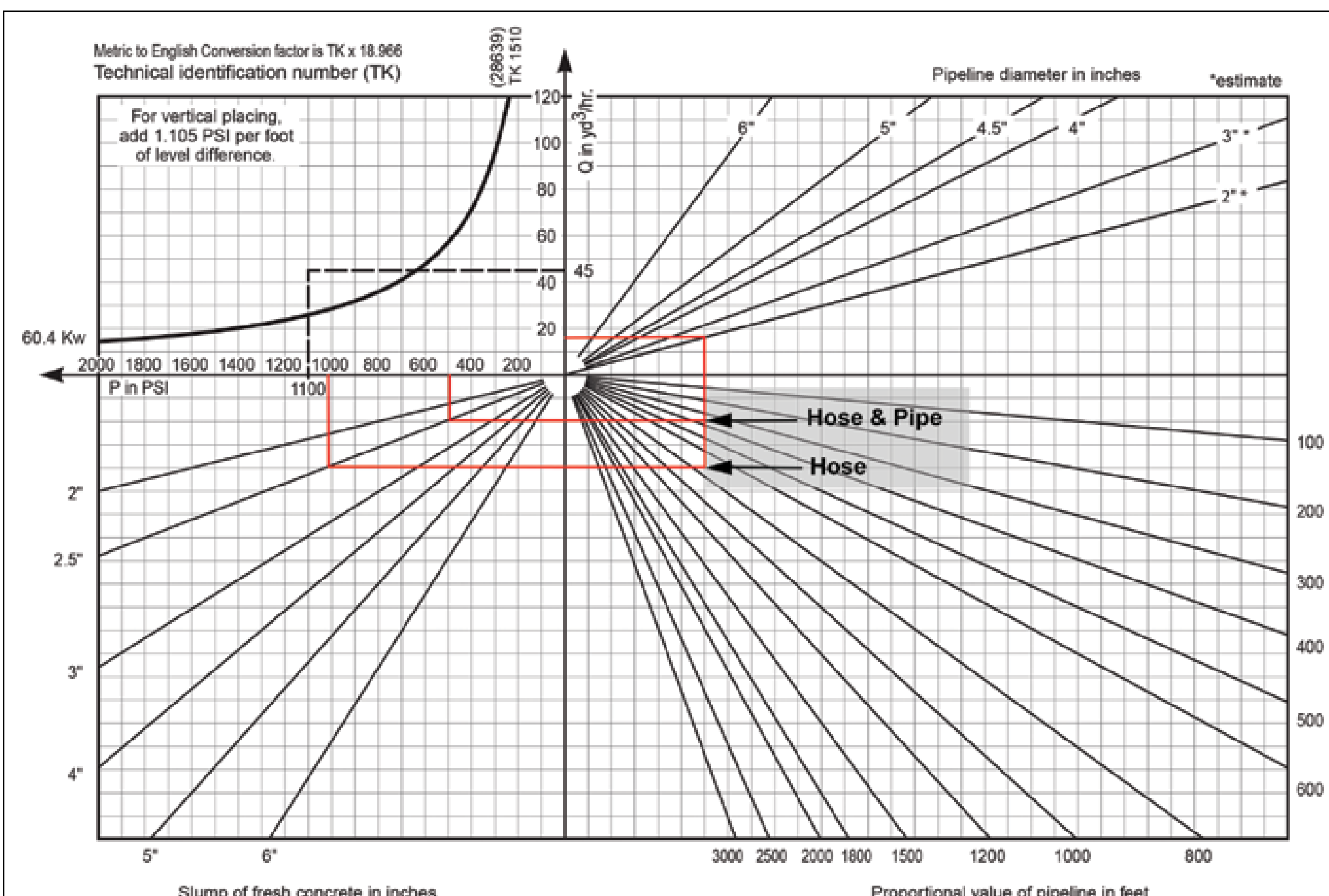


Fig. 3: Concrete pumping nomograph. Nomograph courtesy of Schwing America, Inc.

or worn hoses, and Option 1 may put this job beyond the capabilities of this pump. Conversely, in Option 2, using mostly steel line and a minimal length of hose, the pumping pressure will be under 500 psi (3.5 MPa).

The reduction in pumping pressure achieved by using steel pipeline will result in significant cost savings due to reduced fuel consumption; reduced wear and tear on the pump; and reduced abrasion on the wear parts in the pump, pipeline, and hose. The lower pressures will allow the pump to provide a smoother flow through the line, easing the physical demands on the nozzleman (Fig. 4 and 5). Using steel pipeline instead of hose also allows this smaller pump to be used on longer pushes, avoiding the expense of a higher-pressure pump that would be required if you were using hose alone.

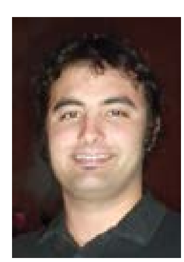
Fig. 4: The pump operator monitors the pipeline during priming. Using steel pipe enabled this mixture to be pumped at lower pressures

Fig. 5: Using hose only, this pump was pressuring out at 4600 psi (32 MPa) in the hydraulic system, or 1130 psi (7.8 MPa) on the concrete. Replacing 50 ft (15 m) of hose with pipeline lowered pressure to 3400 psi (23 MPa) in the hydraulics, or 835 psi (5.8 MPa) on the concrete

The Brass Tacks

Using steel pipeline in place of hose is not only easier on your equipment but also on your bank account. When comparing equal lengths of steel pipeline and hose, the pipeline will cost less than the hose, even after including several elbows and the extra couplings. The steel pipeline can also be expected to outlast the rubber hose in terms of volume pumped and surviving handling and damage at the jobsite. Steel pipe can tolerate a little rough handling that would kink or tear up the protective jacket of a hose. In cases of a plug, shorter lengths of pipe are easier to handle and clean out. Lower up-front cost, in addition to more volume pumped, is a double win for the pumper.

Of course, rubber delivery hose is necessary in concrete pumping and especially wet-mix shotcrete placement. The flexibility of hose just can't be matched by steel pipeline. Hopefully, the benefits of lower pumping pressure, less wear and tear on pumping equipment, less fuel consumption, lower purchase price, and longer expected lifespan all outweigh that lack of flexibility. With these benefits in mind, I hope you will consider sending your truck or trailer out to the next job with a little less hose and a little more steel pipe.



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