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BOX-JACKING - A USEFUL CONSTRUCTION TOOL

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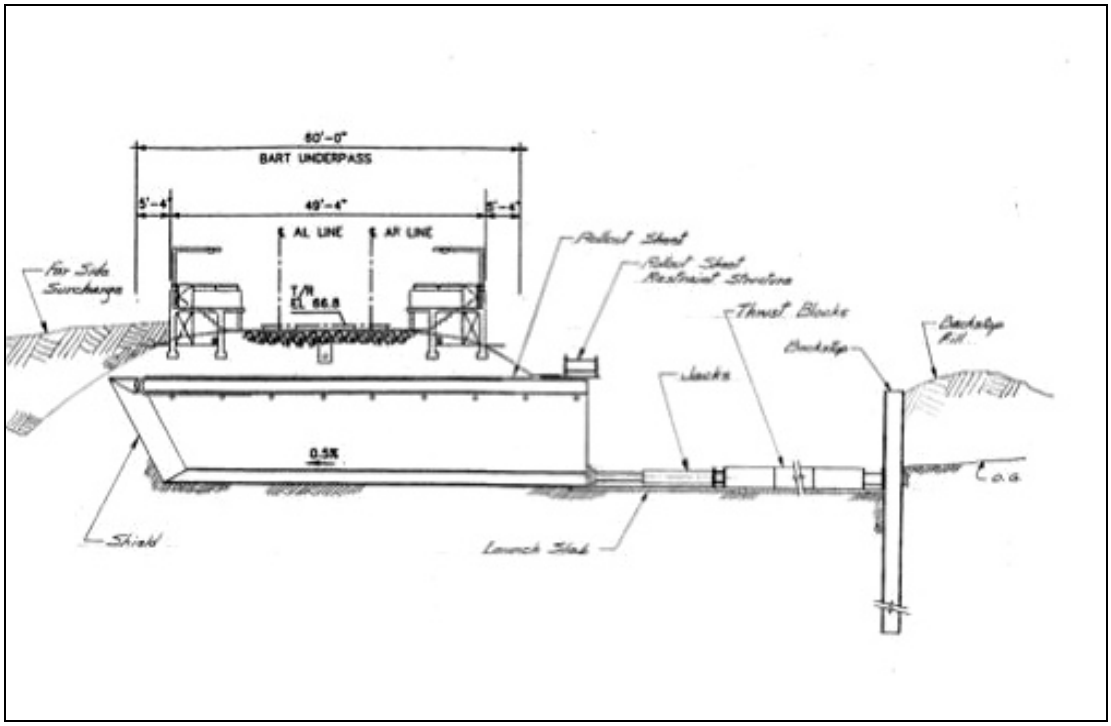
Box jacking is jacking a large precast reinforced concrete box horizontally through the ground, usually beneath a road or railroad that must not be interrupted. The major advantage of the process is its essential simplicity. Only the exact prism of earth that will be filled by the jacked box is excavated. No intermediate ground supports are needed. The structure is built away from the roadway, in the clear, without the constraints of shoring and traffic controls. When the structure is ready, a shield is fitted to the front, hydraulic jacks are installed behind, and the box is pushed into final position while simultaneously the earth is excavated from within.

The actual jacking generally takes only a few days to a week. During that time, traffic is proceeding overhead normally, unaware of the construction below. The non-disruptive nature of the process together with its inherent safety, simplicity and economy make box jacking a useful tool for the practicing civil engineer. This paper intends to bring a greater familiarity with the box jacking process to the reader and then give some considerations and guidelines to assist engineers in designing a project that can be built using the box jacking method.



Schematic for box being jacked beneath railway

Applications

Some examples of potential box jacking projects include storm drains, bike or pedestrian trails, livestock or wildlife undercrossings, conveyors, pipeways and other industrial uses, small bridges, and roadways up to 4 lanes wide. Basically, applications of box jacking depend only on the creativity of the civil engineer designing the project.

Most box jackings Berkeley Engineering has been involved with have been for drainage. The paving incidental to increased urbanization causes larger instant runoffs and larger storm drains are then required. Where these larger channels must pass beneath highways, railroads or the like, tunneling will often be required. Up to 8' or 10' diameter, pipe jacking will often be utilized. But larger sizes are generally rectangular. Placing these larger channels by box jacking will often be the most economical and least disruptive method.

General Description

In principal, box jacking is very simple. The box is built on a greased "launch slab" lined up exactly with its final location. It is then pushed straight ahead, guided by curbs on the left and right to slide straight off the launch slab. A steel shield installed on the front cuts the hole with minimal overcut.

Launch slab - looking towards backstop

The force of the jacks is usually reacted against the earth at the back of the jacking pit but this is not absolutely necessary. A box could theoretically be pulled into place. During jacking, lubricant is pumped around the box to ease its passage through the ground. Upon reaching final location, grout is injected to displace the lubricant and permanently support the overlying ground.

The box is best precast in one large block to the full length required. This is optimal, as rigidity and accuracy can be fairly guaranteed. Where space is limited the box can be cast in halves, thirds, or even more pieces. Although this reduces the total length of thrust column required, it introduces the requirement of employing great care in constructing subsequent box sections to make sure they are exactly aligned with the initial pieces.

The box jacking process can be described in terms of its constituent subsystems, most critical and primary of which is dimensioning. The box must closely fill the hole being cut by the shield at the front, and obviously, not even slightly, overfill it. The mechanical subsystems are as follows:

Jacking - backstop, thrust columns, hydraulic pumps, and jacks
Excavation - shield, face control, digging equipment, transport.
Ventilation - gas testing, fans and fanline.
Lubrication - mixers, pumps, distribution piping and manifolds.
Guidance - lasers, levels, steering provisos.

These systems, acting in concert, can propel the heaviest concrete structure straight into the ground, producing a complete installation with maximum ease and economy. To realize these potential benefits it is very helpful if the project is originally designed with box jacking in mind.

Launch slab looking at portal wall

Applying grease to launch slab

Engineering

What follows are some considerations and guidance for civil engineers designing typical underground projects where box jacking might be utilised:

First, fully assess the negative impacts of open cut. Effects on traffic should be assessed. Many times detours and staged construction are mandated because they are perceived as the only viable method. But box jacking offers another alternative. Box jacking allows the economical placement of large structures under in-service arteries with no disruption.

Layout: The best installation is provided by constructing the box full length in one piece exactly in line with its final location. Sometimes, of course, due to the constraints of the site this may not be possible. But, jacking a single straight box is so advantageous that extra effort to obtain temporary right-of-way or move interfering utilities may be well justified. At one end of the tangent there must be adequate work area to precast the box, in sections if necessary.

Geology. Gather all available geological information - regional, local, and on-site borings. Often overlooked is site history. Investigating, to the extent practicable, the history of the site can be the best guide to what is there and can guide the boring program. Site preparation must be particular to the exact site. It's worth noting that compared to other tunneling methods box jacking is less sensitive to wet ground because the machinery is operating within the box on a concrete roadway. However, the launch slab must be very true and thought and analysis must be given to the elasticity of the jacking slab sub-bed. In very soft ground, strengthening ribs - like an "I" section can be built into the underside of the slab.

Backstop and Jacking Pit: The reaction wall at the back of the pit and the necessary shoring can be one and the same. The jacking forces will be much greater than the active ground loads but still the ground loads must be supported before, between, and after the jacking loads. Reaction walls always seem to move back more at the top so one probably should start with the wall a few inches ahead of where you want it at the top. It will compress as the jacking forces build.

Provide space for the backstop but don't engineer it or prescribe backstop parameters. Allowable bearing stresses should not govern backstop design. Unless there are utilities within the failure prism of the ground the relevant parameter is ultimate strength. Design of the backstop should be generally left up to the contractor. For at-grade installations it is helpful if the designer can make available a source of borrow material from which the contractor can construct the backstop.

Timing: For maximum economy, allow as much time as possible. It may be of advantage to put out the box jacked crossings first on a separate contract to allow that work to get ahead of the mainline channel construction without impeding it. In general, do not mandate around the clock jacking. Crews get stretched, unsatisfactory results may be produced and unsafe conditions may ensue. Around the clock jacking is not necessary.

Box Modifications: Generally only one dimensional modification is done and that is to add thickness to the walls and invert slab so that the thrust of the jacks is backed up by plenty of concrete. Additional rebar, such as stirrups can be added in the local high stress area where the jacks push on the concrete. The box must be made accurately. This is probably the most critical point in the whole process. If the box has high spots outside the design line the force required to push it can be significantly increased.

Slurry piping & rebar in box walls

Casting roof & walls of box

Overall, the essential subsystems can be outlined thus:

1. Site preparation — access, dewatering, etc.
2. Jacking pit
   - Shoring and reaction wall
   - Launch slab
3. RCBox and adaptation for jacking
   a) Dimensional modifications and extra rebar.
   b) Extra close external tolerances
   c) Shield on front
   d) Embeds for lubricating slurry distribution
   e) Pressure cells and instrumentation
   f) Grout holes
4. Jacking System
   - Jacks
   - Hydraulic pumps, plumbing, oil reservoir
   - Thrust columns to backstop
   - Material Handling

5. Excavation System
   - Face excavation
   - Muck Transportation to Shaft
   - Removal from Shaft
6. Ventilation System
7. Guidance System
   - Steering Provisos
   - Lasers
8. Communication Systems

Shield entering ground

Adding thrust columns after jacking 8'

Summary

Box jacking is basically quite simple and straightforward. Such projects will always be easier and more economical if consideration is given in the design stage to the box jacking option. There are critical areas such as tolerancing, face control, and effective lubrication which bear importantly on a successful outcome. Some owners have opted for prequalification of the jacking contractor. Another approach, gaining favor, is to put the job out as design-build. In any case, explicitly allowing box jacking as an option can return significant benefits to the public.

Mucking tunnel w/Cat 933

Jacking completed