FIELD MANUFACTURE AND APPLICATION OF REINFORCED PLASTIC CANAL AND PIPE LININGS

GERALD WESTESEN[1] LEROY PAYNE[2]

ABSTRACT

Unlined canals and ditches seep, erode, and present management problems. Over time concrete lined canals crack and deteriorate. Pipelines and culverts crack, corrode, leak, and function poorly. A problem solution for unlined canals is to install a reinforced plastic lining which is cheaper, more watertight, and more durable than concrete. For deteriorating concrete canals a reinforced plastic lining can be applied to the existing surface. A reinforced plastic liner can be installed in deteriorating pipelines or culverts. Water control structures can be rehabilitated. These measures can be accomplished with a process and machine which mixes and assembles raw materials (plastic components and reinforcing fabric) at the job site, and applies this composite to the surface of a canal, ditch, pipeline, or structure. As the plastic cures it adheres to the underlying surface and creates a reinforced lining. The plastic used can be formulated to fit the requirements of the particular situation. The lining is durable, water tight, and does not have to be earth covered. The lining can be laid in continuous overlapping strips across large canals, or along the length of small canals. Deteriorating pipelines can be lined using an inflatable bladder surrounded by the plastic composite. This paper explains the process and gives examples of its use.

INTRODUCTION

Excessive seepage and leakage from canals and ditches has always been a problem when conveying irrigation water. Seepage causes a myriad of problems which are not limited to the water lost. These problems include water logged soils, poor drainage, and salinity

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[1]Professor, Department of Civil and Agricultural Engineering, Montana State University, Bozeman, MT 59717

[2]Project Director, Innovative Process Corporation, 4643 S. Ulster St. Suite 1520, Denver, CO 80237

buildup. In many areas lands are no longer productive because of these problems and the food supply of entire areas has suffered. Canals and ditches which are not lined support vegetative growth at the water line and underwater areas. This vegetation changes the canal roughness factor, causes an increased depth of flow, and in severe cases restricts water flow completely.

Many types of linings have been tried. Some linings have been successful, while others have failed. Types of linings include concrete, bentonite, and exposed and buried membranes. Concrete is reasonably durable and the technology of formulating, mixing, and placing it is well understood. Concrete is heavy and, if properly placed, smooth. Because of joints and cracking it is not watertight. In areas of freeze and thaw severe heaving and cracking problems can occur.

The use of prefabricated plastic membranes made from polyethylene, polyvinyl chloride, and related formulations has become increasingly common in recent years. These membranes can function well if properly installed but still have some disadvantages. They must be manufactured with factory labor, then transported, and installed. These are all separate operations. When placed the plastic is in a cured state. Thus the plastic does not adhere to the surface on which it is placed. These membranes are formulated as flat sheets. When placed over irregular surfaces they may sustain a puncture immediately or, because of the memory characteristic of plastics, when stretched they will try to return to a flat configuration and eventually puncture. If placed on the soil surface the sheet stock plastics are subject to wind and water movement. An earth cover is often necessary adding to the overall expense. Seaming these sheet stocks can also be difficult and time consuming.

In an effort to overcome these shortcomings of traditional lining materials a new process has been developed, tested, and patented (United States Numbers 4,872,784 4,955,759 4,955,760 5,049,006 5,062,740, other U. S. and foreign patents pending) by the Innovative Process Corp. This process is called the Mobil Reaction Extrusion Process (M-REP). The process can blend chemicals, inert fillers, and fabrics into a site specific lining material, and place the lining where needed.

THE LINING PROCESS

The machinery and mechanisms for conducting the fabrication/lining process can be mounted on a trailer or vehicle. This unit carries drums of raw plastic material, catalysts, filler such as calcium carbonate or recycled plastic, and fabric such as fiberglass or polypropylene cloth. A mixing system allows addition of components such as catalysts, pigments, foaming agents, UV stabilizers, and anti-oxidants. The resulting mixture discharges from a main hose which moves back and forth over the fabric to insure wetting. The "wet" fabric is also pulled through a trough filled with material and between rollers to insure uniform and proper composite thickness.

For lining canals and ditches the fabric is anchored at the beginning of each strip to be lined. This strip can be applied lengthwise on a small ditch or perpendicular and across a large canal. The plastic formulation impregnates and coats the fabric as it unrolls. The resulting composite is laid out as a "wet" blanket on the surface to be lined. This blanket drapes and conforms to the surface. Since thermoset plastics have strong adhesive properties the composite adheres to the surface as it cures. The fabric holds the reacting mixture in place and minimizes flowing during curing. Cure time varies from a few minutes to several hours depending on the type and amount of materials used. Subsequent strips are overlapped thus producing a seamless, watertight surface.

The lining can be applied at a linear rate of about 10 m/min. The area lined will depend on the width of the fabric used and machine capacity. The process is extremely fast compared to alternative lining methods which helps minimize labor costs. The final liner thickness depends on the fabric thickness and the number of layers of fabric used. Typical thickness is approximately 4 mm. Various widths of fabric can be used depending on job requirements. Because this is a "wet" process the lining strips are simply overlapped. No heating or gluing is required to form a seam.

The same machine with minor modifications can be used for lining deteriorating pipes. The key to the process is an inflatable bladder which is placed inside an envelope of fabric. The fabric is impregnated with plastic, then pulled through an existing pipe. The bladder is then inflated forcing the assembly to the shape of the surrounding pipe.

The seam is simply overlapped. Air pressure supplied by a compressor or tank is maintained inside the bladder until the plastic sets. The lining adheres to the existing pipe as with canals and ditches. The resultant structure has the strength of the newly constructed reinforced plastic pipe plus any strength contributed by the existing pipe. After the plastic sets, the bladder can be stripped or left in place depending on the situation.

Lining around structures and the rehabilitation of existing structures can also be accomplished with this process. When lining around structures strips of "wet" composite can be hand placed. These strips are overlapped as necessary. Vertical slopes, which are extremely difficult to rehabilitate with other lining materials, can be readily lined. Lining is accomplished by anchoring the top of the composite with stakes, then draping it down and over the area.

RESINS, FABRICS, AND FILLERS

A very large number of resins, fabrics, catalysts, and fillers can be used in this process. The resins used to date have been primarily urethane elastomers and polyesters. These are thermoset type materials and become solid or semi-solid with the addition of a catalyst. The urethane used results in a plastic which is similar in appearance and feel to automobile tires. Thermoset polyesters are extremely versatile and used in many applications. A few of these applications are boats, recreational vehicles, cultured marble, automobile exterior parts, paneling, bowling balls, and polymer concrete.

The time to initial material set can be changed by varying the type and amount of catalyst used. There are many grades of resins available. The plastics industry has verified material properties and information is available on factors such as strength and elongation in handbooks and texts. The designer can select the resin and catalyst to meet job requirements. Properties such as corrosion resistance are readily achievable with appropriate resin selection.

Fabrics used have included fiberglass, polyester, and polypropylene. The fabric must carry the resin. Too wide a mesh allows the resin to drip off. Too tight a fabric results in poor penetration of the resin. A fabric such as fiberglass can be selected to provide high strength, and multiple layers of fabric can be used when necessary. If high strength is not required very inexpensive fabrics can be used. The strength and properties of the final product is in the designers hands through resin, fabric, filler, and additive selection.

Filling a resin is analogous to adding gravel to a cement-water mixture when making concrete. By filling the resin, costs can be reduced and properties of the lining can be changed. Filling gives the product greater mass and durability. Fillers which have been successfully used are calcium carbonate dust, shredded tires, and granulated scrap plastic.

This process should provide an ideal way to use recycled plastics. Even the fabric could be a woven mat made from recycled shredded plastic fibers. In agricultural applications the product is used outside, and any odor from recycled plastic should be quickly dissipated. The finished product does not have to be perfect. Seeps finding their way to the natural earth are acceptable as long as they are not severe. Minor imperfections can be patched. This use of recycled plastic is well removed from the end user, which is in complete contrast to using recycled plastic to make bottles, for example.

EXAMPLES OF INSTALLED LININGS

A test program has been underway for three years and a total area of approximately 15,000 m^2 has been lined. This field testing is in addition to numerous laboratory tests of various formulations to verify properties. Linings have been installed at different and diverse locations which have included ponds, canals, ditches, and water control and conveyance structures. Four sites and installations are described in more detail.

The first site involved a reservoir which had steep side slopes, drop structures between reservoir sections, and water control structures. Lining was placed by using the machine in a normal fashion where possible. This means that as the machine moved forward the fabric impregnated with resin was unrolled and dropped into place. In addition, lining was placed by swinging 30 m lengths of resin impregnated fabric out and over the reservoir bottom with a crane. The lining was placed in over lapping strips so no gluing or sewing of seams was necessary. On the steep side slopes the strips of fabric were anchored at the top, then draped into place. Vertical slopes were successfully lined. This lining was placed over a wet mud bottom which would have been impossible to work on with any other type material. Strips of lining were hand placed around gates and other water control structures.

The second site involved a concrete lined ditch having a bottom width of 25 cm, a top width of 2.4 m, and 1:1 side slopes. A section of the ditch after lining including a metal turnout is shown in Figure 1. The concrete in this ditch had been badly damaged by cracking and corrosion. In some places short sections of concrete were completely missing. The only preparation for lining was shoveling out some sediment

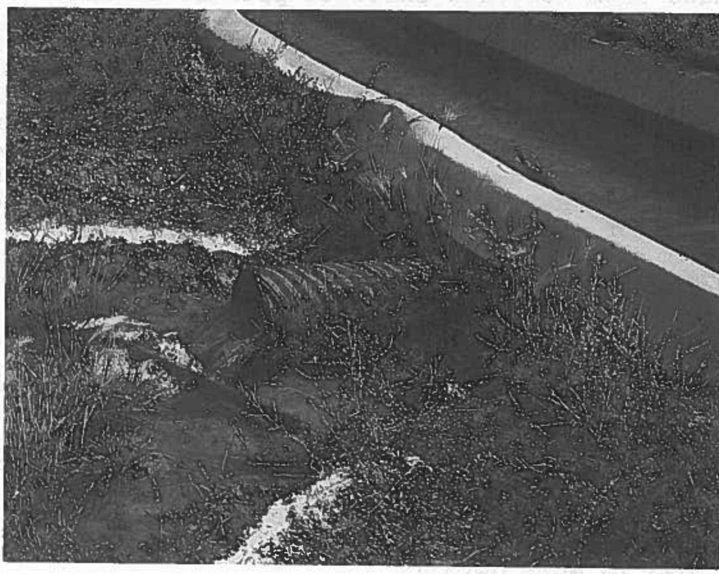

Fig. 1 Plastic lining of a concrete ditch

deposits on the ditch bottom. A 400 m section of this ditch was lined with a semi-rigid material. The lining was done in a snow storm and was done quickly with the machine moving continuously and parallel to the ditch. The lining has survived one Montana winter and the ditch is being used for irrigation. In areas where the concrete lining had completely fallen away the plastic used had the strength and rigidity to build a new ditch bank for short distances. Using this process for lining deteriorating concrete linings appears to have great potential.

The third site lined shown in Figure 2 was on an existing section of canal which traversed a shale hillside about 10 m above a farmer's field. Through this section more than 50% of the flow was lost to seepage. The farmer's field was in effect a swamp with a loss of productivity and a threatened law suit. Attempts had been made for years to make this 10 m wide, 450 m long section watertight. The canal was 150 km from any concrete ready mix plant and the job was too small to justify bringing a plant to the site. Thus concrete was economically precluded. Bentonite had been tried unsuccessfully and simply washed through the rock. Sheet stock plastic would have been

Fig. 2 Plastic lining of a rock/earth canal

punctured on the sharp rocks, and soil for covering the sheet stock was not available.

The farmers in the area, with some technical assistance, roughly shaped the canal cross section. Using this process the leaky section was lined in a two hour period. The lining was applied in overlapping straps perpendicular to the canal. The necessary raw material was transported to the site in a small truck. The lining is functioning, leaks and seepage have been eliminated, and the farmer is happy.

Repairing deteriorating wood or concrete structures can be extremely difficult. This process offers a solution. Figures 3 and 4 show two wood structures which were failing due to age, settlement, and broken

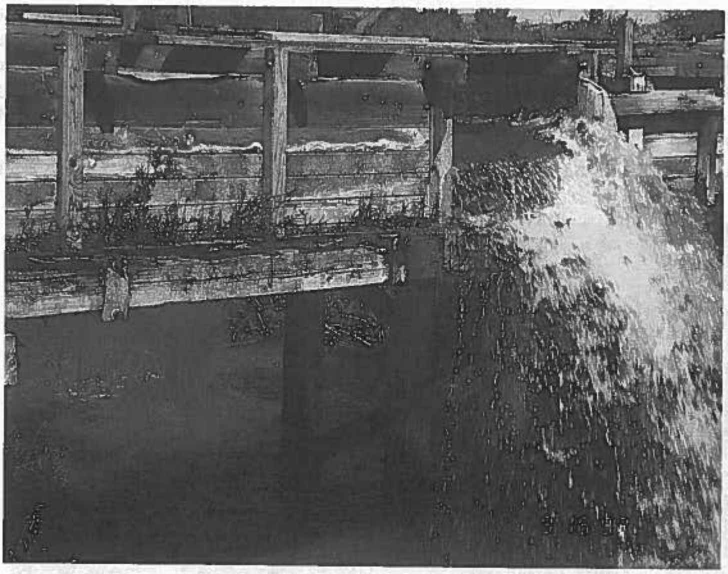

Fig. 3 A deteriorating wood flume

boards. The concrete floors upstream of the flumes was so badly cracked that streams of water were flowing underneath the structures. The structure were draped with a polyester type plastic and fiberglass fabric. A new plastic structure was partially built over the old wood one. The concrete floor was sealed and covered with the same material. The repairs have been successful for one season, and this may provide an expedient way to temporarily or possibly permanently extend the life of this type structure. In Figure 3 and 4 note the plastic lining showing above the wood boards. This plastic lining covered the wood and concrete.

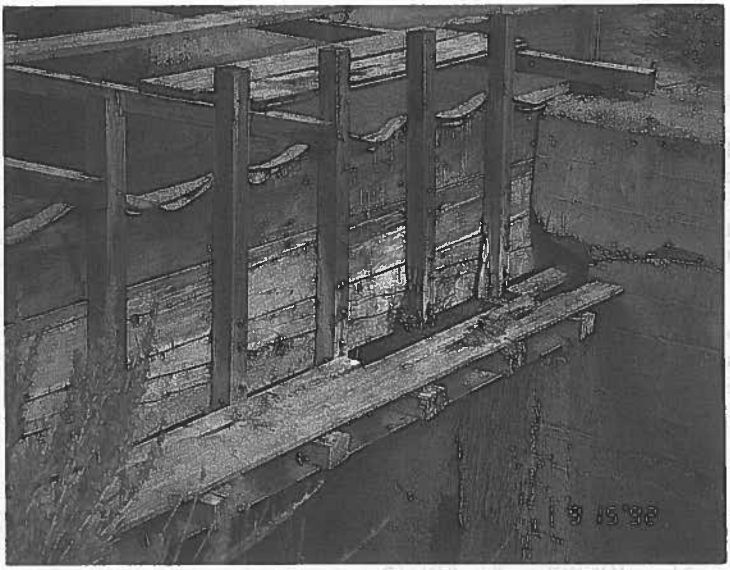

Fig. 4 A wood/concrete structure after repair

PIPE LINING

There are tens of thousands of kilometers of deteriorating concrete irrigation and sewer pipe in the world. There are also countless culverts which carry water through embankments and under roads which are deteriorating and need replacement. This process can be used to seal and rehabilitate existing pipe by, in effect, making a new pipe inside the old one. If the old pipe is structurally sound, only a minimal sealing layer of fibre reinforced plastic may be necessary. If structural strength is needed, it can be provided through specification of the correct resins and layers of fabric. In a similar manner, corrosion resistance can be obtained by specifying particular resin formulations for the layer in contact with liquid.

When rehabilitating culverts the pipe is normally relatively short and open on both ends. The alternative to structurally lining the existing pipe is excavation and installation of a new pipe. This excavation involves more than just digging. Traffic may have to be stopped or detoured with attendant hazard and liability problems.

SUMMARY

A new process is available to take the factory to the field and to manufacture a multitude of plastic based products. Very logical immediate applications of the process are for the lining of canals and ditches, the lining of existing pipelines, lining around structures, and the rehabilitation of deteriorating structures. The process can utilize recycled plastics for filler or for the fabric. The market potential of the process is huge, and may lead to the creation of a major new industry. Billions of pounds of virgin plastic will be needed, and the process has world wide potential.

RELATED PUBLICATIONS

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