Recycling concrete pavements

Crushing old pavement produces good quality coarse aggregate at high production rates

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Why recycle concrete pavements? The key reasons are cost savings and reduced environmental impact. High-quality, new aggregates may be scarce or costly to transport. Hauling away removed pavement material adds to the cost. And finding a disposal site for removed material near the paving project is difficult, especially in urban areas. Besides saving money, recycling old pavement on site reduces the environmental effects of waste hauling and disposal.

Recycling was first done on Michigan paving projects because specifications required it from 1983 to 1985. This was done to get the Michigan construction industry involved in the process and to develop the necessary procedures. On jobs since 1985 recycling has been optional. It's estimated that recycling has saved about $3 to $5 per ton of coarse aggregate used. In total, the Michigan Department of Transportation (MDOT) has recycled more than 400 lane-miles of concrete pavement, or nearly 3 million square yards.

Breaking

Recycling starts with breaking the old pavement. Early jobs used a drop-weight type pavement breaker

Figure 1. Early pavement recycling jobs used a drop-weight type pavement breaker.

Figure 2. Workers used a 30,000 foot-pound pile hammer pavement breaker to break this pavement. Particles look rather fine in places, but in general pieces are about 2 to 3 feet in size.

Figure 3. Attached to a backhoe, a rhino horn rips reinforcing steel from the pavement and windrows broken pavement on the grade.

(Figure 1). Pile driving hammers were used later. They are supported either on wheels or in an earthmover and usually are rated at about 18,000 foot-pounds. Contractors have found that the shape and size of the shoe portion contacting the pavement has a significant effect on the way the pavement is broken. It also affects the amount of the hammer's energy used to break the pavement, as opposed to just setting up vibrations.

On some jobs, contractors have used 30,000 foot-pound pile hammer pavement breakers. Modifying the breaking shoe allowed effective breaking of large quantities of pavement in a day. It broke the surface into rather fine particles in places (Figure 2), but in general the pieces of pavement are relatively large, 2 or 3 feet in size, when removed for hauling to the crusher.

A "guillotine" type machine was used on one of MDOT's highway projects. Its capacity can be up to 56,000 foot-pounds.

Vibratory, sonic, or resonant breakers are used mostly for special purposes. The oscillating beam and shoe on the front of the machine are powered by a rotating eccentric weight, at about 44 cycles per second. This machine creates much less earth vibration than the drop hammer types. It also operates at lower production rates and breaks the pavement into smaller pieces.

One contractor used the sonic device on continuously reinforced concrete (CRC) pavement and effectively separated the steel from the concrete. The mats were lifted out of the broken pavement on the grade. Another contractor using typical methods was not able to separate the steel efficiently from the CRC pavement and wasted the material instead of using it in the new pavement.

Pavement breaking is likely to generate complaints from local homeowners if the houses are near the pavement that is being removed. Complaints sometimes occur when maximum earth vibrations exceed 0.03 inch per second at the house and are likely when vibrations are 0.06 inch per second or more. Vibrations caused by 18,000-foot-pound hammers get down below this probable complaint level at roughly 140 feet from the source. The 30,000-foot-pound hammer reaches the 0.06 level at about 200 feet. But it is many hundreds of feet from the guillotine-type drop hammer before that low a level is attained.

For projects where breakers are used close to houses and at the same grade level, be ready for complaints from homeowners whose houses are shaken by this vibration.

Removal

After cracking the pavement, contractors remove it from the grade and prepare it for transport to the crusher. Some contractors use a backhoe with an attachment at the end called a rhino horn (Figure 3). This horn acts as a ripper to break the reinforcing steel and windrow the broken pavement on the grade. It separates some of the reinforcing steel from the broken pavement on the grade and breaks remaining steel into pieces small enough for workers or electromagnets to remove at the crusher. It also gets the pavement ready to load with end loaders.

Other contractors load with backhoes directly off the grade without the rhino horn. They are likely to pick up more of the base material and incorporate it in the recycled aggregate. Weather affects the amount of base materials and fines picked up during removal. Some fine granular material can be screened away however.

The main concern when removing the broken concrete is not to pick up material you don't want in the mix. If the construction site is on clay soils, the loading, hauling, and stockpiling operation can incorporate clay into the salvaged concrete pile; and the reclaiming operation from the salvage pile to feed the crusher can pick up still more. Once clay balls are incorporated there is no reasonable way to get them back out. Extreme care should be taken if the pavement being salvaged or the

Figure 4. Screens directly below this primary crusher separate fines from the crusher output.

stockpile, crusher, or plant site rests on a clay subgrade.

Crushing

Early jobs were done with jaw-type crushers. A grizzly or screen placed ahead of the crushers on some early jobs separated some of the fine material before it was fed into the primary jaw crusher. On later jobs, screens directly below the primary crusher separated fines from the crusher output (Figure 4). Secondary crushers are used with most jaw crushers.

Another type of crusher used effectively on many jobs is the impact-type crusher. It generates a little bit more fine material than a jaw crusher, but production is quite high and it's effective in handling large pieces of steel.

Uses of recycled materials

Fine aggregate. Paving concretes can be made and have been made with significant amounts of recycled fines. However, these fines are more angular, porous, and absorptive than natural sands. This makes the mix more harsh and more difficult to handle and consolidate than it would be otherwise. Consider carefully the use of recycled fines. They may contain dirt picked up off the subgrade or at the crusher and also may be contaminated with salt that penetrated the old pavement.

Recycled fines aren't suitable for use in drainage layers beneath the pavement. Some of the cementitious material attached to the surface of the fines goes into solution when water percolates through. A precipitate then forms in the drainage structure or on the geotextile fabric used to wrap the drain. Because this plugs the drain, MDOT no longer allows the use of recycled fines in drainage layers of the pavement base.

Coarse aggregate. Michigan primarily uses the coarse fraction of recycled aggregate for paving. This material also is more porous and absorptive than the original aggregates. We carefully watch for contamination—clay balls, bituminous patching materials, joint seals, expansion joint fillers, and tramp steel. If a significant quantity of any of these is present in the final product, problems result.

Consider the amount of harmful materials in the old pavement before deciding to recycle it as coarse aggregate. If there was a serious problem with popouts caused by soft stone or chert, it might be advisable not to recycle the original pavement. Some low-quality aggregate, however, may be improved by recycling. For instance, reducing the particle size of coarse aggregate that causes D-cracking is known to improve its performance. Long-term pavement performance depends on high-quality aggregates. If the materials in the old pavement caused a very short life, you should seriously consider using new or better materials this time.

Recycling may degrade very high quality aggregates slightly, but MDOT has found that recycling generally produces good quality aggregate at high production rates. The old pavement will provide more than enough coarse aggregate for repaving. Crushing a 9-inch pavement provides enough coarse aggregate to pave a new 10-inch pavement with concrete shoulders on both sides.

Paving

Paving is pretty much straightforward. There is somewhat more harshness to the mix, especially if you use recycled fines. With the advent of harsher mixes from recycled concrete, the consolidating effort of the paver often is insufficient to obtain the compaction needed. Close attention is needed. Consolidation is related to the condition and function of the vibrators on the pavers. Adjustment can be made on many of the newer model pavers with hydraulic vibrators. It's not a subject that gets a lot of attention on paving jobs, but using recycled pavement makes it worthwhile.

During reconstruction of the northbound Lodge Freeway (M-10), 115,000 tons of old pavement were removed, crushed, and reused. MDOT and the contractor made good use of the lessons learned from the 14 previous major recycling jobs. Our recycling program has progressed from an experiment to a cost-effective way for conserving resources.

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