Econocrete Pavements: Current Practices

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This report represents a compilation of recent experience in the United States with the construction and design of econocrete pavements (lean concrete that may be made with low-cost, locally available aggregates that do not meet conventional specifications). Interest in the use of econocrete has developed in the last few years due to the high cost and dwindling supplies of high-quality aggregates in some areas of the country. Described are the different uses of econocrete as subbases under concrete pavements, base courses under asphalt surfaces, composite concrete pavements, and shoulders. The report also discusses aggregate requirements and mix design for econocrete, laboratory investigations, and field research and gives current practices and recommendations for construction.

Greater use of local aggregates, substandard aggregates, and recycled pavement materials can bring about considerable economy in pavement construction. In many areas, the supply of high-quality aggregates is becoming depleted, which has caused greatly increased material costs and hauling costs.

To reduce pavement costs and preserve high-quality aggregates, the Federal Highway Administration (FHWA) in 1975 issued a notice (1) to encourage the use of econocrete in pavement subbase, base, composite pavements, and shoulder designs. Econocrete is a name that has been given to a portland cement concrete that may be made with a relatively low cement content and with low-cost aggregates or recycled materials that do not necessarily meet standards for normal concrete aggregates. In areas where high-quality aggregates are in short supply, substantial quantities of substandard local aggregates are often available. These can be used as an aggregate in econocrete base or subbase courses when a proper mix design is used to provide appropriate levels of strength and durability for these applications.

USES OF LEAN CONCRETE OR ECONOCRETE PAVEMENTS

In the last few years, in the United States, the use of lean concrete or econocrete pavements has increased. Since 1975, econocrete has been constructed on more than 50 highway and airport paving projects in 20 states. These projects include econocrete used as the following:

1. Subbase course under concrete pavement,
2. Composite concrete pavement,
3. Base course under asphalt surface, and
4. Shoulders adjacent to concrete pavement.

This paper presents recent developments in the uses of econocrete, aggregate requirements and mix proportioning, laboratory investigations and field trials, and construction methods.

Subbases

The greatest use of econocrete has been as a subbase under a conventional concrete pavement. This is a nonmonolithic construction, where the surface course of normal concrete is later placed on a hardened econocrete subbase.

Data for several projects are given in Table 1. Recycled pavement materials were used as aggregates in the econocrete for a number of these projects.

Figure 1 shows typical cross sections for highway projects in Georgia and Colorado. The subbase is built wider than the pavement or extended beneath the shoulders, which provides beneficial support for the pavement edge. Generally, this design has been used for pavements that will be subjected to high volumes and weights of traffic. One of the reasons for selecting an econocrete subbase (2) is to provide an erosion-resistant subbase surface that should help inhibit joint faulting of undoweled joints.

Composite Concrete Pavements

In a composite concrete pavement, the surface course of full-strength concrete is cast monolithically with the lower-course econocrete, which results in full bond between layers. The bond is achieved by coarse-texturing or scarifying the surface of the lower course while the econocrete is still in the plastic state and then immediately placing the surface-course concrete. The monolithic action of a composite pavement results in an efficient structural design section.

Figure 2 shows typical cross sections of composite pavement projects constructed in Iowa and North Dakota. On these projects, the monolithic top course wraps around the edges of the base by about 38 mm (1.5 in) on either side. Data for several projects are given in Table 2. The Iowa projects used recycled materials as aggregates.

Composite concrete pavements have a great potential for economy, especially in areas where high-quality aggregates are in short supply. The practice has been to place a relatively thin monolithic surface course on a thicker econocrete lower course. As a result, a greater proportion of the pavement section uses less-expensive materials.

Base Courses Under Asphalt Surface

Concrete bases that have asphalt surfaces have been used for years by several cities for major arterial streets and by some state highway departments for ramps on Interstate highways. Usually on these projects, the aggregates have met normal concrete aggregate specifications and the cement contents are somewhat less than for normal concrete but not generally as low as for econocrete.

In many foreign countries, lean concrete bases have been used extensively for highways, streets, and airport pavements. This experience has been with both dry (compacted with rollers) and wet (compacted with internal vibration) lean concrete. The specifications vary somewhat from country to country—some permit lower-quality aggregates; most of them use low cement contents that give 28-day compressive strengths in the range of 6.9-13.8 MPa (1000-2000 lbf/in^2). The practice has evolved to use low-cement-content, low-strength mixtures so that the seriousness of reflection cracks in the asphalt surface is minimized.

In the United States in the last few years several projects have been constructed by using econocrete base courses. Table 3 is a partial list of these projects and Figure 3 shows some typical cross sections.

Shoulders

Econocrete shoulders may be constructed with new concrete pavements or rebuilt shoulders adjacent to

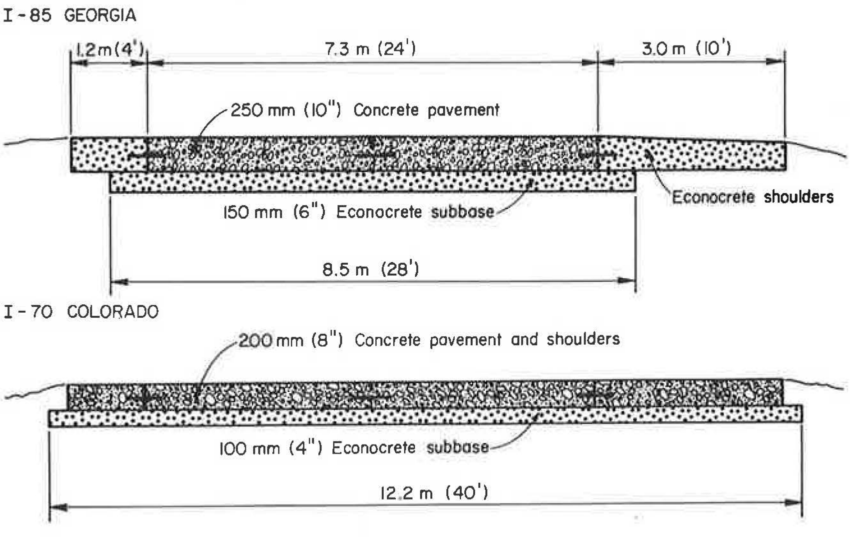
Table 1. Partial list of econocrete subbases under concrete pavements.

Location	State	Length (km)	Width (m)	Cement Content[a] (kg/m^3)	Subbase Thickness (mm)	Surface Thickness (mm)	Year
Routes							
AZ-360, Superstition Freeway, Tempe	AZ	1.9	9.9	153	102	152	1977
CA-91, Artesia Freeway, Compton[b]	CA	4.8	15.2	139	122	203-229	1975
I-5, north from Stockton	CA	11.1	11.6	-[c]	127	203-229	
CA-1, Monterey	CA	3.4	11.6	-[d]	107	203-229	1972
CA-1, Tracy bypass near Ft. Ord, Mojave	CA						1970
I-70, Rifle	CO	16.9	12.2	148	102	203	1976
I-70, Arvada	CO	2.7	11, 4	133, 118[e]	152	203	1979
I-75, Sarasota area	FL	53.0	12.2	208	152	229	1979
I-85, LaGrange	GA	17.5	8.5	148	152	254	1976
Entrance ramps, Atlanta airport	GA			160	127		1979
I-72, Monticello	IL		7.9	148	102	203	1976
IL-78, Kewanee	IL	8.0	7.9	148	102	203	1975
Freeway Rt. 534, Burlington	IA	4.0	7.9	178	102	229	1976
US-30, Cedar Rapids	IA	9.0	7.9	178	102	229	1976
I-129, Sioux City	IA	0.8	7.6	178	102	216	1977
IA-520, Sioux City	IA	4.5	7.6	178	102	229	1978
I-680, Missouri River east to I-29	IA	5.0	7.6	178	102		1977
I-380, Cedar Rapids	IA	0.6	7.9	178	102	254	1978
I-580, Reno	NV	1.0					1979
I-80, Wendover	NV	8.0	12.8	175-219	102	203	1978
US-52, south of Winston-Salem	NC	8.7	8.5	119 minimum	102	229	1979
I-680, north of Ohio Turnpike, Youngstown	OH	4.0	12.8	-[f]	102	203	1971
test track		12.1	11.9	-[g]	102	254	
Route 220, Williamsport	PA	1.9	8.5	178	152	229	1979
I-77, Edgemoor	SC	20.0	8.5	139	152	229	1979
I-95, Dorchester Co.	SC	1.6	8.2	126	152	267	1975
I-77, near Blythewood	SC	15.1	8.2	126	152	229	1978
I-77, Columbia	SC	2.3	8.5	126	152	229	bid 1979
I-77, Richburg	SC	15.1	8.5	126	152	229	bid 1979
I-77, ramps, Fort Mill	SC	0.6	6.7	95, 133	152	229	1974
I-24, north of Nashville	TN	6.6	8.2	148	127	254	let 1977
I-80, west of Salt Lake City	UT	4.1	15.2	162	102	279	1979
I-15, Beaver	UT	24.1	12.8		102	241	1979
Airports							
Jacksonville International, runway keel[b]	FL		15.2	148	152	356	1975
Jacksonville NAS, apron	FL				152	254	
Tampa, runway, taxiway, and extension	FL		48, 25	107-130	152	406	1979
Standiford Field, Louisville, taxiway	KY		23	-[h]	305	356	1978
Shreveport, taxiway	LA		24.1	162	152	356	1975
Tupelo	MS			181	152	203	1978
Pittsburgh International, runway and taxiways	PA		30, 15	142	152	279-406	1979
Pittsburgh International, taxiway extension	PA		23	142	152	356	let 1979
Tocumen Airport, runway, taxiway, and apron	Panama			-[i]	229-279		1976

Note: 1 km = 0.62 mile; 1 m = 3.28 ft; 1 kg/m^3 = 1.69 lbf/yd^3; 1 mm = 0.039 in.

[a] Cement content of subbase. [b] Recycled aggregates. [c] 10 percent. [d] 8.5 percent. [e] Plus 59 kg/m^3 fly ash. [f] 12 percent. [g] 7 percent. [h] 4 percent. [i] 6 percent.

Figure 1. Typical cross sections for econocrete subbases.



existing concrete pavements. The requirements for the shoulder concrete are not as demanding as for the main roadway pavement. Normally, shoulders carry very little traffic, and the abrasion resistance, strength requirements, and aggregate quality requirements are lower. However, the econocrete mix design should take into account the freeze-thaw durability requirements, depending on climatic considerations.

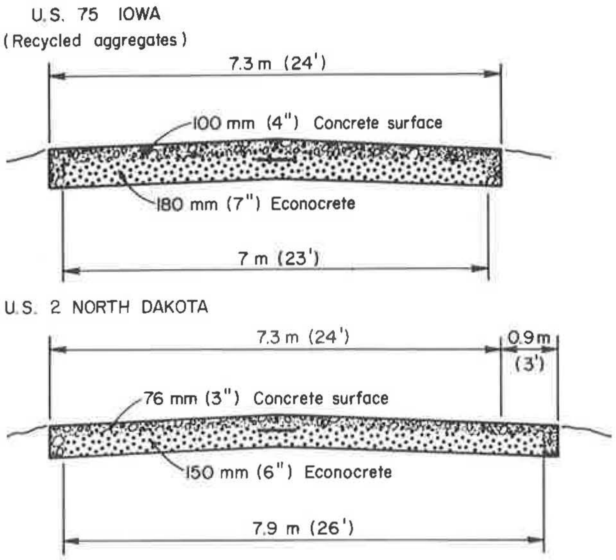
Econocrete shoulders should improve main-line pavement performance by providing a tight, sealed joint between pavement and shoulder and by reducing load deflections at the pavement edge.

Data on econocrete shoulder projects constructed recently are given in Table 4. On most of these projects, the shoulder-pavement joint is tied with deformed tie bars. Frequently, rumble strips are formed in the plastic concrete to discourage travel on the shoulder.

FLORIDA ECONOCRETE TEST ROAD

Important research is currently being conducted by the Florida Department of Transportation on the Florida Econocrete Test Road. This 10.6-km (6.6-mile) test road on US-41 north of Ft. Myers was opened to traffic in April 1977. Test sections of econocrete were built at three levels of cement contents [130, 160, and 202 kg/m^3 (220, 270, and 340 lb/yd^3)] by using an aggregate that was a limerock material from an excavation.

Figure 2. Typical cross sections for composite concrete pavements.



Some test sections had specially reinforced concrete surfaces, but of particular interest on the test road is the performance of the 14 sections of econocrete that had plain concrete or asphalt surfaces. In these, the lower courses of econocrete are 230 mm (9 in) thick with surface courses of 75 mm (3 in). The econocrete was constructed without joints. For the sections surfaced with concrete, the surface was bonded to the econocrete subbase, and joints in the surface concrete were spaced at 4.6 m (15 ft) in some sections and 6.1 m (20 ft) in others; right-angled and skewed joints were placed in different sections.

After 2.5 years of heavy traffic, accumulating more 80-kN (18 000-lbf) equivalent axle loads than were applied at the American Association of State Highway Officials (AASHO) Road Test, the 14 econocrete sections that had plain concrete or asphalt surfaces are in excellent condition. Continued observation of these sections by periodic inspections and measurements of rideability and other factors should provide valuable information on the performance of econocrete composite pavements.

AGGREGATE REQUIREMENTS AND MIX DESIGN

Some of the restrictive specification requirements for concrete aggregates relate to the performance characteristics of the exposed pavement surface—where substandard aggregates may cause undesirable surface conditions, such as lack of abrasion resistance, slippery pavements, or pop-outs. Many substandard or marginal aggregates that do not meet normal specifications may be acceptable when used in econocrete as a lower course in the pavement structure.

Aggregate gradation requirements for econocete are also not as strict as those for normal concrete. In many cases the regular gradation of aggregate from the crushing plant, or crusher-run as it is sometimes called, is satisfactory without the addition of sand. Aggregates that meet gradation specifications for untreated base course have also been used as is. Conventional concrete aggregates have also been used with modified mix designs.

Some specifications designate only the top size of aggregate and the amount that passes a 75-μm (No. 200) sieve. It is noted that gradation specifications should be modified to meet local aggregate gradations if suitable econocrete mixtures can be produced; then

Table 2. Partial list of composite concrete pavements.

Location	State	Length (km)	Width (m)	Cement Content[a] (kg/m^3)	Lower-Course Thickness (mm)	Surface-Course Thickness (mm)	Year
US-41, test road, Ft. Myers	FL	1.3	7.3	130	229	76	1976
US-41, test road, Ft. Myers	FL	1.8	7.3	160	229	76	1976
US-41, test road, Ft. Myers	FL	1.3	7.3	202	229	76	1976
Intersection in St. Joseph County	IN			279	152	51	1978
US-75, Rock Rapids[b]	IA	0.8	7.3	279	178	102	1976
US-75, Sioux City[b]	IA	1.6	7.3	335	← 229 full depth →		1976
IA-2, between Bedford and Clarinda[b]	IA	27.9	7.3	371	← 229 full depth →		1978
I-96, temporary, Detroit	MI			178	152	178	1976
US-31, Shelby Road, interchange ramp	MI			178	102	102	1976
US-2, Rugby to Leeds	ND	41.4	8.2	190	152	76	1977

Note: 1 km = 0.62 mile; 1 m = 3.28 ft; 1 kg/m^3 = 1.69 lbf/yd^3; 1 mm = 0.039 in.

[a] Cement content of lower course.

[b] Recycled aggregates.

Table 3. Partial list of econocrete base courses under asphalt surface.

Location	State	Length (km)	Width (m)	Cement Content (kg/m^3)	Base Thickness (mm)	Surface Thickness (mm)	Year
CA-7, Long Beach Freeway	CA	10.3		136	320	137	1977
I-5, Santa Ana Freeway	CA	4.0		136	183	122	1977
CA-198, Coalinga	CA	9.5		160	244	61	1979
CA-198, Coalinga	CA	9.7	8.5	160	244	61	1978
Frontage Road, Santa Monica	CA	0.3		196	183	122	1979
Fifth Street and ramp, Santa Monica	CA	0.6		196	259	122	1979
US-41, test road, Ft. Myers	FL	0.6	7.3	130	229	76	1976
US-41, test road, Ft. Myers	FL	0.6	7.3	160	229	76	1976
Harrison Avenue, Rockford	IL	3.9	18.3	252	229	76	1978
US-83, Cole Harbor	ND	10.1	11.3	148[a]	152	38	1977
US-2 and 52 bypass, Minot	ND	4.0	11.3	148[a]	152	64	1978
US-2, west of Grand Forks	ND	20.6		148[b]	152	64	let 1979
Local road, Lock Haven	PA	0.2		112	152	64	1977

Note: 1 km = 0.62 mile; 1 m = 3.28 ft; 1 kg/m^3 = 1.69 lbf/yd^3; 1 mm = 0.039 in.
[a] Plus 59 kg/m^3 fly ash.
[b] Plus 44 kg/m^3 fly ash.

Figure 3. Typical cross sections for econocrete base courses.

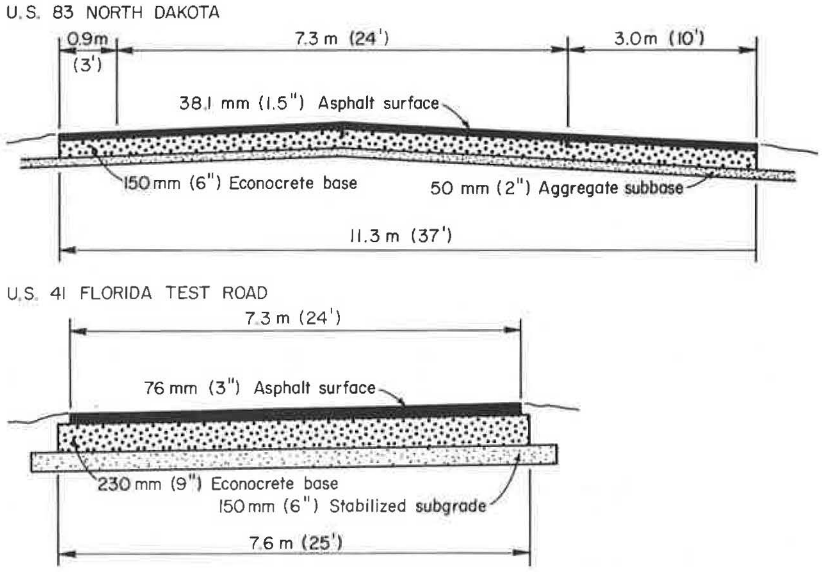


Table 4. Partial list of econocrete shoulders.

Location	State	Length (km)	Width (m)	Cement Content (kg/m^3)	Thickness (mm)	Year
US-41, test road, Ft. Myers	FL	0.6	1.2, 2.4	202	152	1976
I-75, Sarasota area	FL		3.0		229-152	1979
I-85, LaGrange	GA	17.5	1.2, 3.0	252	152	1976
I-16, 56 km west of Savannah	GA	19.3	1.2, 3.0	252	254-152	1976
MI-14, west of Plymouth	MI	2.4		178, 208, 237	203-152	
US-52, Davidson-Forsythe Counties	NC	8.7	1.2, 3.0	267	229-152	1979
US-83, Coleharbor	ND	10.1	0.9, 3.0	148[a]	152[b]	1977

Note: 1 km = 0.62 mile; 1 m = 3.28 ft; 1 kg/m^3 = 1.69 lbf/yd^3; 1 mm = 0.039 in.
[a] Plus 59 kg/m^3 fly ash.
[b] Surfaced with 38 mm of asphalt.

a gradation specification for the project can be written to control the variability of the aggregate.

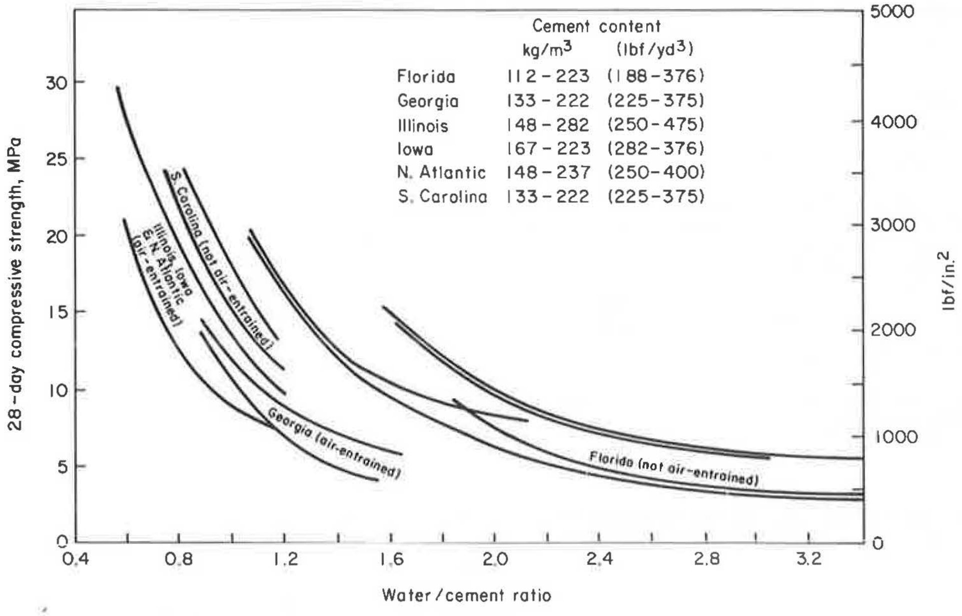
Data obtained from recent laboratory test programs and econocrete construction projects (3) indicate that a wide range of aggregates may be used. Some of these aggregates are materials not processed to the degree that normal aggregates are. Most have more fine material that passes the 150-μm and 75-μm (No. 100 and No. 200) sieves than is acceptable for normal concrete, but this is not necessarily objectionable for econocrete because the extra fines help supply needed workability for mixes that have low cement contents.

On several recent recycling projects, old concrete and asphalt pavements have been crushed and used as aggregates for econocrete.

Mix Design

For the proportioning of econocrete mixtures, the normal procedures and tests for concrete are followed with these exceptions: (a) a single aggregate is sometimes used rather than a combination of coarse aggregate and fine aggregate and (b) the cement content is usually less than that for normal concrete. A primary requirement is that the econocrete be workable—easy to mix and place, capable of adequate consolidation by

Figure 4. Compressive strength versus water-cement ratio.



vibration, and cohesive enough to resist excessive edge slumping when placed with a slip-form paver. The second requirement is that the hardened concrete have the level of strength and durability appropriate for the exposure conditions.

Workability of concrete depends primarily on the aggregate characteristics, air content, and the cement content. Since the cement content is low in lean concrete (which could cause poor workability for normal aggregates), the workability may be enhanced by (a) the existence of extra fines in the aggregate; (b) higher than normal amounts of entrained air; (c) addition of fly ash, water-reducing admixtures, or workability agents; or (d) a combination of these.

In the laboratory, trial mixes with selected cement contents are used to determine a mix design that will give the desired workability and slump [usually in the range of 25-75 mm (1-3 in)] for the aggregate or combination of aggregates. Typical gradation specifications for econocrete are given below (1 mm = 0.039 in).

Sieve Designation	Percentage Passing Sieve A	B	C
50 mm	100		
38.1 mm		100	
25.0 mm	55-85	70-95	100
19.0 mm	50-80	55-85	70-100
4.75 mm	30-60	30-60	35-65
425 µm	10-30	10-30	15-30
75 µm	0-15	0-15	0-15

Properties of the hardened lean concrete are then determined by strength tests and, if appropriate, durability tests. Strength requirements have not been definitely established but it is generally considered that the strength requirement will vary with the structural use and that high strengths are not required when the econocrete is not used as an exposed surface. Limited data on freeze-thaw durability of lean concrete indicate that high air contents may be required to achieve a high degree of resistance to concrete freeze-thaw tests. It has not been established whether the durability requirements need to be as stringent as those for a concrete surface course. It is expected that test requirements for econocrete used as a lower course of a pavement will be similar to those required for cement-treated bases. Additional research and performance experience are needed to better define durability requirements and appropriate laboratory tests. It appears that air contents on the high side of the range recommended for normal paving concrete may be needed for econocrete constructed in freeze-thaw areas. Freeze-thaw resistance requirements for econocrete used as an exposed surface (such as pavement shoulders) should be the same as for normal concrete.

Laboratory Investigations

Results of several recent laboratory test programs are described here to provide some preliminary guidelines for mix design. Results of the studies are described in more detail elsewhere (3).

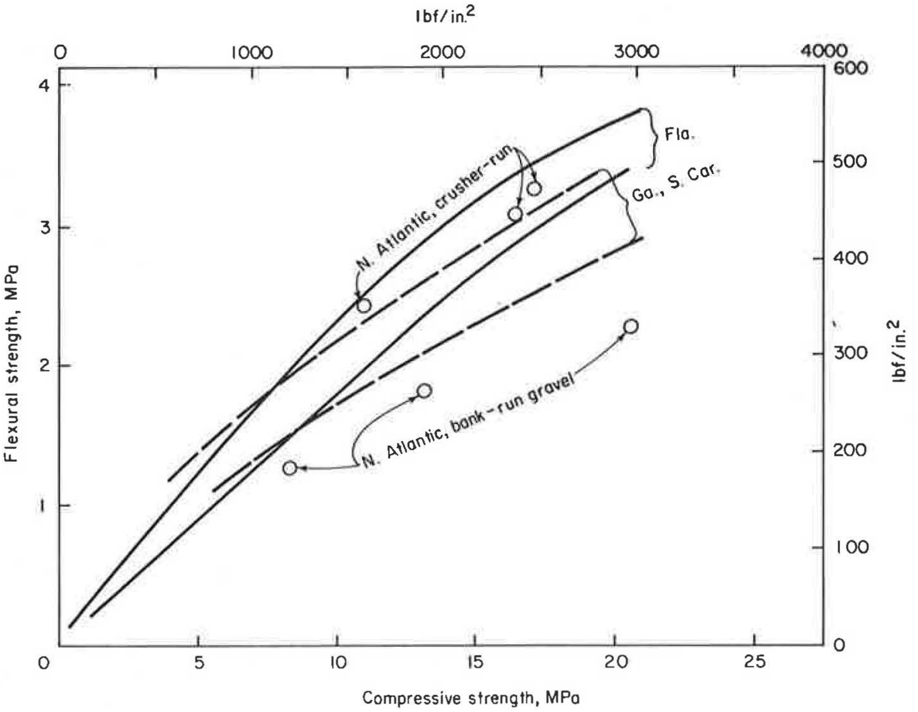
The Georgia Department of Transportation laboratories tested crushed stones from four sources (4). In the initial tests, a mix that contained 140 kg/m³ (235 lb/yd³) of cement without air-entraining or water-reducing admixture was found to be harsh and unworkable and exhibited heavy bleeding. As a result, all subsequent trial mixtures contained an air-entraining and a water-reducing admixture. These mixtures were cohesive and workable and appeared to be suitable for placing with conventional paving equipment.

The second phase of the Georgia investigation involved mixes that had cement factors of 133, 178, and 222 kg/m³ (225, 300, and 375 lb/yd³). Air contents for these mixes were kept at about 6.5 percent and slumps were in the range of 25-50 mm (1-2 in).

Compressive strengths for these mixes, as well as for the other studies discussed later, are shown in Figure 4, where the general relation of strength to water-cement ratio and air content is apparent.

The South Carolina Highway Department conducted tests initially on crushed stones from two sources with about 178 kg/m³ (300 lb/yd³) of cement and with air-entraining and water-reducing admixtures. Following these tests, additional aggregates (a crushed limestone and a granite-gneiss crushed rock) were tested with cement contents in the range of 133-222 kg/m³ (225-375 lb/yd³), air contents of about 3 percent, and slumps of about 12 mm (0.5 in). A water-reducing admixture was used but not an air-entraining admixture. These mixes had considerably higher strengths (see Figure

Figure 5. Flexural strength versus compressive strength.



4) than those in the first series of tests, which had higher air contents and slumps.

The Florida Department of Transportation conducted a test program on econocretes (5) made from four common sources of Florida base-course aggregates: Ocala limerock, a low calcium oolite, coquina, and a stabilizing grade of limerock. The aggregates were taken from the quarry without processing with the plus 50-mm (2-in) material removed. Mix designs with cement contents of 112, 167, and 223 kg/m^3 (188, 282, and 376 lb/yd^3) were made with no admixtures. Slumps ranged from 0 to 12 mm (0.5 in); air contents were 1-2.5 percent. These high-calcium aggregates generally contained more fines and had lower specific gravities and higher absorptions than normal. They required relatively high water contents to develop plastic mixes, which contributes to the high water-cement ratios shown in Figure 4.

Lower strengths were obtained than those determined in other studies on more conventional aggregates at equal cement contents. However, when compared with the pattern of strength versus water-cement ratio for other materials shown in Figure 4, the strengths are higher than normal—possibly due to some beneficial characteristics of the aggregates in their reaction with cement.

Laboratory studies and field trials were conducted in Illinois to determine mix design requirements of econocrete used as a subbase and as a shoulder. Aggregates included mixes of gravel with a natural sand and various base course aggregates. Cement contents were varied from 148 to 282 kg/m^3 (250 to 475 lb/yd^3), and air-entraining and water-reducing admixtures were used. Air contents were generally in the range of 6.5-8 percent and slumps were 19-38 mm (0.75-1.5 in). Twenty-eight-day compressive strengths between 11 and 32 MPa (1600 and 4700 lbf/in^2) were obtained on these mixes.

The Iowa State Highway Commission conducted an extensive study of 27 different aggregate sources. Mix designs were made with three cement contents: 167, 195, and 223 kg/m^3 (282, 329, and 376 lb/yd^3). Air content for most of the mixes was in the range of 5.0-7.5 percent; slumps were generally between 20 and 50 mm (0.75 and 2 in). A water-reducing admixture was used in almost all mixes. The strengths for the conditions stated are plotted in Figure 4 and varied from 8 MPa (1200 lbf/in^2) at a water-cement ratio of 1.27 to 27 MPa (3900 lbf/in^2) at a ratio of 0.59.

A laboratory study (6) was conducted on two aggregates from North Atlantic states—a siliceous limestone and a bank-run gravel, both having excessive amounts of material passing a 75-μm (No. 200) sieve. Cement factors of 148, 193, and 237 kg/m^3 (250, 325, and 400 lb/yd^3) were used. The mixes were designed to contain from 6 to 8 percent air and had about a 25-mm (1-in) slump.

Substantial quantities of air-entraining admixture were required to generate the air void system, and the dosage increased as the cement content decreased.

The 28-day compressive strengths for these mixes fell in the same band in Figure 4 as the other air-entrained mixes of the Iowa and Illinois studies. These strengths ranged from 8.3 MPa (1200 lbf/in^2) at a water-cement ratio of 1.08 to 21 MPa (3000 lbf/in^2) at a water-cement ratio of 0.65.

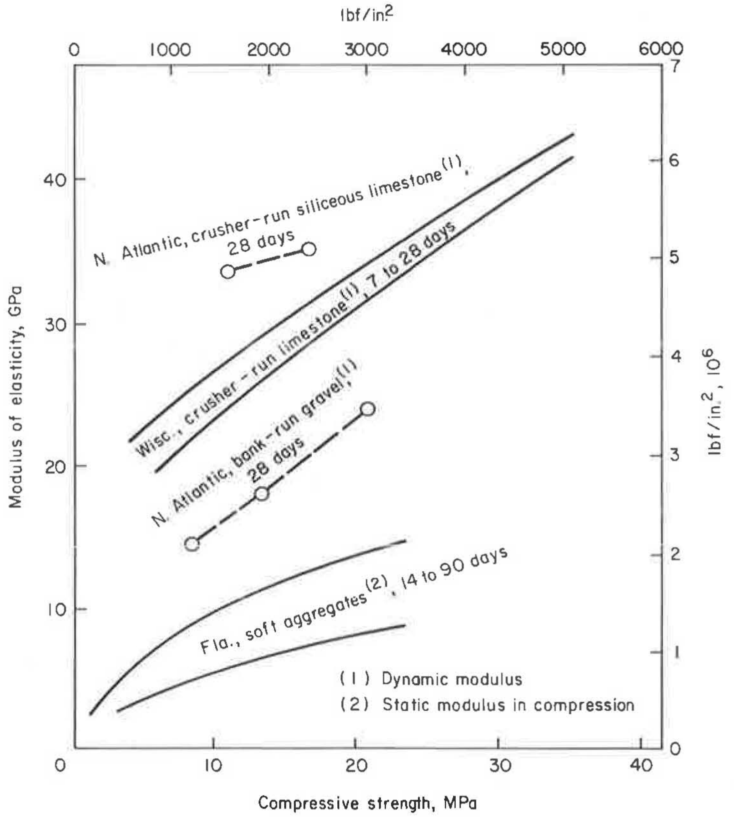
Three hundred cycles of concrete freeze-thaw tests (ASTM C666, procedure B) were also run on these mixes, and it was found that at least 7 percent air was required to provide resistance to the test conditions.

In some of these laboratory studies, flexural strengths and moduli of elasticity were determined as well as compressive strengths. Figures 5 and 6 illustrate the data obtained.

Summary of Material Requirements and Mix Design

Laboratory investigations and field installations indicate that the desirable properties of econocrete to be used as a base or subbase course are achieved with cement factors in the range of 120-210 kg/m^3 (200-350 lb/yd^3), giving 28-day compressive strengths between 5.2 and 10.4 MPa (750 and 1500 lbf/in^2). For the lower course in a composite concrete pavement, cement factors and

Figure 6. Modulus of elasticity versus compressive strength.



strengths may be at these levels or higher—up to those for normal concrete. Other recommendations are to attain slumps in the range of 25-75 mm (1-3 in), and air contents equal to that recommended for normal concrete and somewhat greater [6-8 percent air for concrete made with 25-50 mm (1-2 in) maximum size aggregate] for freeze-thaw areas. Additional research is needed to better define appropriate tests and criteria for freeze-thaw resistance.

CONSTRUCTION OF ECONOCRETE

Econocrete components of a pavement structure are constructed in essentially the same manner and with the same equipment as normal concrete pavements. The only differences, depending on the application, may be (a) the jointing practice and (b) the treatment of the interface between the base or subbase and surface courses. The following recommendations are made based on current experience.

Joints

For subbases and base courses, joints in the econocrete are not considered necessary. Hairline cracks will develop in the econocrete; but experience has shown, for the low strength levels recommended and with the interlayer treatment discussed below, reflection cracking will usually not occur in concrete surfaces and will not be serious in asphalt surfaces.

For composite concrete pavements, the jointing practices should be the same for normal concrete pavements.

For shoulders, joints are placed to match the joint pattern in the main-line pavement or, for continuously reinforced main-line pavements, joints in econocrete are placed at short intervals—4-5 m (15-20 ft).

Interlayer Treatments

For subbases, the current practice is to leave the econocrete untextured to prevent mechanical bond with the concrete surface course and to apply an ample coat of wax-based concrete curing compound as a bond breaker. If the curing compound becomes worn off due to traffic or other causes, another coat should be applied before the surfacing concrete is placed.

For base under asphalt surface, the current practice is to tine or coarsely scarify the econocrete surface to promote mechanical bond and cure with asphalt emulsion or resin-based concrete curing compound.

For composite concrete pavements, the econocrete surface is coarsely tined. No curing compound is applied since the concrete surface course is placed immediately on top.

The American Association of State Highway and Transportation Officials has recently adopted a guide specification for econocrete (7) that discusses construction items in detail.

SUMMARY

In many areas of the United States, the supply of high-quality aggregate for pavement construction is becoming depleted. Materials from existing sources are becoming expensive or unavailable due to restrictive zoning, environmental controls, and appreciated land values. Due to these problems, a serious interest in the use of econocrete (a lean concrete made with local, low-cost aggregates not necessarily meeting conventional specifications) began in about 1975. In this paper, an attempt has been made to present a summary report on a number of paving projects that used econocrete for base and subbase courses, composite concrete pavements, and shoulders; to discuss laboratory investigations and field research; and to report current practices and recommendations for aggregate requirements, mix design, and construction methods for econocrete pavements.

REFERENCES

1. Pavement, Subbase, and Shoulder Designs Using Econocrete and the Initiation of NEEP Project No. 20—Experimental Pavement Construction Using Econocrete. Federal Highway Administration, Notice N5080.34, April 23, 1975.
2. California Trials with Lean Concrete Base. California Department of Transportation, Sacramento, Interim Rept., CA-DOT-TL-5167-3-75-37, Oct. 1975.
3. Econocrete, Report No. 1. American Concrete Paving Association, Arlington Heights, IL, Aug. 1975.
4. R.W. Allen. Lean Concrete Mix Design Studies for Use as Concrete Pavement Base Course. Office of Materials and Tests, Georgia Department of Transportation, Forest Park, 1973.
5. T.J. Larsen, H.W. Harling, and F.E. Howard. Strength Properties of Lean Concrete. Florida Department of Transportation, Gainesville, Research Rept. 80, Dec. 1973.
6. M.H. Wills, Jr. The Potential for Econocrete in the North Atlantic States. Materials and Mix Design Committee, American Concrete Paving Association, Arlington Heights, IL, Nov. 12, 1974.
7. Section 310—Econocrete, or Lean Mix Portland Cement Concrete Base Course. In Guide Specifications for Highway Construction, American Association of State Highway and Transportation Officials, Washington, DC, 1979.

Construction and Performance of Sand-Asphalt Bases

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Sand-asphalt base construction practices and field performance are described based on extensive field inspections and interviews with state transportation personnel in Florida, Georgia, Maryland, and South Carolina. The results are also summarized of laboratory fatigue and rutting tests performed on both sand-asphalt and sand-stone asphalt mixes. Laboratory studies indicate that the fatigue characteristics of a sand-asphalt mix can be generally controlled by (a) limiting the void content to 12-15 percent, (b) using asphalt contents greater than 5.5-6.5 percent, and (c) designing the mix with a Marshall stability as high as practical. Important variables that affect rutting in a sand-asphalt mix are asphalt content, Marshall stability (or air void content that appears to be related to Marshall stability), and the characteristics for the aggregate. The specific effects of these variables are presented for selected mixes. Sand-asphalt and sand-stone blend asphalt mixes can be successfully used as bases on primary and Interstate highways. Rutting in pavements constructed by using 150- to 200-mm (6- to 8-in) sand-asphalt base is typically between 8 and 15 mm (0.3 and 0.6 in). An allowable rut depth for design purposes of 10 mm (0.4 in) is recommended for primary and Interstate pavements. The 50-blow Marshall mix design method can be used for sand-asphalt bases, provided rutting and fatigue resistance of the mix is taken into account. The blending of up to 75 percent crushed aggregate with sand offers an excellent way to decrease rutting and increase fatigue life of the mix while still using local sand.

Due to rising energy costs, construction of pavements by use of local materials, often of low quality, has become a necessity. Pavements constructed by using sand-asphalt mixes, if not properly designed, may undergo excessive rutting or premature fatigue distress. The purpose of this paper is to investigate the use of sand-asphalt in base-course construction. The findings presented are the result of field inspections and interviews with personnel of four selected state transportation organizations and a comprehensive laboratory investigation of fatigue and rutting characteristics of sand-asphalt mixes.

SELECTED CONSTRUCTION PRACTICES AND FIELD PERFORMANCE

Sand-asphalt mixes are used in the southeastern portion of the United States, primarily in the coastal plain areas. The construction practices and field performance of sand-asphalt bases in Florida, Georgia, Maryland, and South Carolina are summarized in this section. Other southern coastal plain states also use sand-asphalt bases.

Florida

The Florida Department of Transportation has used sand-asphalt bases extensively throughout Florida and has used, to a much lesser extent, sand-stone-asphalt blends. Pavements in Florida that have sand-asphalt bases were found to show good performance and surface rutting usually less than 12 mm (0.5 in). A cross slope of 2 percent is used in Florida and no problems of ponding water were reported. The surface cracking that develops is typically longitudinal. Because of the favorable climate and good subgrade conditions that occur throughout most of the state [usually a California bearing ratio (CBR) of 15-25], relatively light structural sections are used in Florida. For pavements subjected to high volumes of traffic, a 75- to 130-mm (3- to 5-in) thick asphalt-concrete (AC) surfacing mix is placed over approximately 250 mm (10 in) of sand-asphalt base. A 300-mm (12-in) prepared subgrade is used below the base. For low-volume roads, a 40-mm (1.5-in) thick sand-asphalt surfacing is placed over 150-200 mm (6-8 in) of unstabilized limerock base.

In metropolitan areas that have concentrated traffic that require relatively high stability, a sand-asphalt base that has a stability of 3.3 kN (750 lbf) is sometimes specified. Usually, however, a sand-stone blend AC mix is used to meet higher stability requirements. This