Woodrow J. Halstead, Charlottesville, Virginia, chairman

Workshop Topic 1
BINDERS

Consideration was first given to existing binder systems and to possible alternatives that might be developed. A list of these is as follows:

1. Asphalt products,
2. Hydraulic cements (portland, blended, slag),
3. Lime,
4. Pozzolanic materials (lime-fly ash and others based on atmospheric temperature reactions among calcium-silicon-water),
5. Sulfur,
6. Wood lignins and resins,
7. Tars (derived from coal),
8. Petroleum resins (epoxy-polyester), and
9. Sulfates (primarily calcium sulfate wastes from scrubbers to remove sulfur oxides from stock gases).

An examination of each of these types of materials resulted in the conclusion that little possibility existed for the development of completely new binder systems. The first 4 in the list generally represent the major materials now available. Asphalt products are now used in about 90 percent of all U.S. highway pavement structures and are also the mainstay in maintenance efforts. The hydraulic cements, principally portland cement, provide the binder for most highway structures and a substantial portion of high types of pavements. They also have a significant role in soil stabilization. Lime and lime-fly ash or other pozzolanic systems have significant roles in base course construction and stabilization.

The most likely probability of a new binder that can be substantially used appears to be sulfur. This may be used either as the total binder or in combination with asphalt. In the present state of development, the sulfur-asphalt combinations appear to have more promise.

The interest in wood lignin and wood resins is derived primarily from the fact that wood is a renewable resource. Lignin wastes have been used in some "stabilization" and dust palliative projects, but because of their water solubility have not provided permanence. Some studies now under way show possibilities of developing a useful product from wood wastes, but such efforts are still in the feasibility stage.

Tars derived from various coal processing activities can be used as highway binders, and a body of technology is available. However, the overall better performance of asphalt as a highway binder and the greater value of tar as a fuel, usually at the site of its manufacture, make it highly unlikely that appreciable amounts of tar will become available in the near future for highway construction in the United States. However, in the long run, should coal be developed as the principal source of liquid fuel, it is possible that usable binders could be manufactured from residual products or even directly from coal.

Petroleum resins are extremely expensive, require large amounts of energy in their manufacture, and therefore cannot be considered for highway construction except for special applications in limited quantities. The waste sulfates may have application in embankments or base courses. However, this product was not discussed. The technology for its use relates more closely to the problems of solid waste utilization.

In the final analysis, the binder problem becomes one of establishing the optimum use of the available systems. It is necessary to consider cost and energy effectiveness of trade-offs among possible alternatives. The availability of specific binders for each construction project is an important factor in such considerations since the cost of transporting materials quickly changes both cost and energy consumption. Consequently, a national policy that one type of construction should be used in preference to another cannot be established; decisions must be reached on a project-by-project basis. This leads to a recognition of the need for better knowledge of energy-use factors for all activities relating to highway construction. A number of agencies have conducted preliminary studies and some values are becoming available, but differences exist in the factors published for the same operation. A priority effort to establish universally acceptable energy use factors is needed, and it is recommended that the Transportation Research Board, through one of its established committees or by a special task force, undertake this task.

One of the major differences of opinion that exists is the question of whether the Btus in asphalt should be considered in calculating the energy used in asphalt construction. Although it is true that the asphaltic portion of the original crude oil represents a potential energy source, once the petroleum is refined in such a manner that asphalt is a product and reaches the market for highway use, that product becomes a construction material and the Btus in the asphalt are no longer available as energy.

It so happens that when the Btus in asphalt are included as "energy," computations indicate that the requirements for asphalt construction exceed those for equal areas of portland cement concrete construction. The picture is reversed if the asphalt Btus are not included as energy. In this case the computations indicate that portland cement concrete requires more energy. The asphalt industry and the portland cement industry are both quite concerned over the "image" created by publication of such comparisons, and each defends its own interpretation. However, to the highway engineer these figures have little meaning. The energy of transporting needed ingredients to a job site significantly changes both the costs and energy-use factors and could be the determining factor for many projects.

Although the question of whether the Btus in asphalt count as energy may be academic to the highway engineer faced with a decision on a given project, it is of importance to those concerned with overall national energy policies. Eventually a decision may be needed as to how best to use the total potential energy available to the United States. A complete discussion of the pros and cons of various decisions or policies regarding energy use was beyond the scope of this conference. I will note only that the decision as to what process will be used in refining a given crude is not made by the highway engineer. Technology is available to refine petroleums by "cracking" so that no asphalt is attained. Also, the same "heavy ends" can be used to make either heavy grades of commercial fuel oil or asphalt, and the balance between these two uses is controlled somewhat by the relative demands as well as other economic considerations. It is somewhat fortunate for the highway industry that certain restraints now exist that make infeasible the complete cracking of the heavy ends to increase production of gasoline or lighter fuel oils. Similarly, restraints exist that make it undesirable in view of antipollution requirements to burn all asphalt as a fuel. The chief factor in this regard is the sulfur content. Most asphalts contain combined sulfur that is extremely difficult to remove or cannot be removed by existing technology. Accordingly, existing regulations for maximum sulfur dioxide in exhausts cannot be complied with if such products are burned with present equipment.

In view of these restraints and with the knowledge that a substantial lead time is required to change refining processes, it appears that, barring political decisions to withhold imports of crudes, the supply of asphalt for highway construction will be adequate for the near future. However, the long-range possibilities are that greater energy demands will produce shifts in refining and combustion technology that will ultimately reduce the supply of asphalt available to the highway industry. At the present time it is not possible to predict how soon this will occur or what will be the total impact, but preparations should be made for this eventuality. We cannot sit back and wait for asphalt supplies to disappear before taking action. We must establish alternatives and conduct research or develop needed technology for making needed shifts in materials. In particular, the increasing cost of energy and the shrinking highway dollar make it imperative that all possible measures be taken to optimize use of energy and materials. Considerations must be given to both cost effectiveness and energy effectiveness. Under present circumstances the most cost effective may not be the most energy effective; but provided artificial restraints on the cost of energy are removed, eventually differences would likely disappear. It was also recognized that cost effectiveness would probably control highway decisions, unless regulations or political restraints are introduced.

The discussion brought out the following findings and recommendations.

CHANGES WITHIN EXISTING TECHNOLOGY

1. Optimize design. It was the consensus of all groups that design and specification requirements have not kept pace with the development of knowledge. Although much of the improvements that can be made in this area will relate to construction practices, important savings can be made in amounts of binder used and the energy required for their efficient use. For example, the principle of retaining large amounts of untreated material within an envelope of stable material such as portland cement concrete or asphalt concrete was discussed. The support provided by such "retaining walls" provides adequate saving in binder and, of course, money.
2. Eliminate artificial restraints. A factor relating to design changes is the need to review specification and procedures with the purpose of eliminating artificial restraints and of permitting alternatives based on cost or energy effectiveness. Contractors should be permitted to adjust their procedures to minimize consumption of energy as long as the product furnished complies with contractual requirements.
3. Use emulsions in lieu of cutbacks for tack coats. In this instance some regulatory pressures may be required. It was reported to the conference that in many areas the attitude of highway construction or maintenance engineers is that, as long as cutbacks are available, they will use them. On the other hand, asphalt manufacturers have taken the attitude that, as long as there is a demand, they will continue to furnish cutbacks. Continued use of cutbacks for tack coats as well as other purposes continues to waste the energy in petroleum distillate used (gasoline or kerosene) and to create air pollutants when evaporated.
4. Evaluate practices for crack sealing. Current sealing practices often result in a waste of materials and effort. Even though sealing may be desired and needed, present practices usually result only in temporary bridging of a crack with little or no beneficial effect.
5. Design asphalt mixtures to use less asphalt per volume unit of construction. Several possibilities exist. For example, larger aggregates that have less surface area to be covered with asphalt may be used. In other design variations, more filler may be added. In this case, asphalt plus filler would provide the "mortar" and less asphalt would be used for equal amounts of "binder" (considering the mortar as the effective binder).
6. Design portland cement concrete to meet the needs. Do not use greater thickness or higher cement content than is needed for the job.
7. Use fly ash or other available pozzolans in portland cement concrete. These products can be used to replace part of the cement. Such mixes should be designed and proportions properly selected. A one-for-one substitution, all other things being equal, may not provide the best product.

INNOVATIVE TECHNIQUES

1. Use recycling procedures that provide for making use of the asphalt in old pavements as a significant portion of the binding agent in the new pavement. Usually a special softening or rejuvenating agent is required. However, use of these techniques not only saves binder but considerable energy if accomplished with a minimum of hauling.

The energy of breaking up the old pavement and processing must, of course, be considered on the negative side when the overall effectiveness of such measures is evaluated.

2. Use special water reducing agents in portland cement concrete to provide equal strengths and performance with less cement. Recent results with these "super" water reducers indicate that full-scale trials are warranted.

3. Use combinations of stabilizing materials to provide improved performance with less material. For example, studies have shown that, with some heavy clays, an initial treatment with a small amount of lime followed by additional treatment with portland cement may be a more effective means of stabilizing such materials than treatment with equivalent amounts of either lime or portland cement used separately.

RESEARCH NEEDS

Discussions revealed that a number of things relating to binders are being tried and in the opinion of some were ready for implementation; but others believed more study was needed. Some of the major items are listed below.

1. Use of emulsion mixtures in lieu of hot mix. This suggestion has received widespread attention because of the apparent significant saving in energy by the elimination of aggregate and asphalt heating. However, most of the conferees agreed that we need to know more before this idea can be universally endorsed. We need to know more about the properties of the individual emulsions and the residual properties of the cured mixture. We need to have better knowledge of fatigue properties and other performance characteristics. We also need a better understanding of the energy trade-offs involved. Although savings of energy during actual mixing and laying may be evident, the loss to the driving public by longer traffic delays and possible adverse effects on durability must be assessed. In this regard NCHRP Synthesis 30, Bituminous Emulsions for Highway Pavements, brings together a wealth of knowledge that should be used as a guideline to develop further research and experimental construction that will provide needed answers.

2. Sulfur and sulfur-asphalt systems. Laboratory research and results of field studies in Canada and France show considerable promise for the use of sulfur as a significant extender for asphalt as well as a means of using otherwise unsuitable sands for aggregate. Field trials have begun in the United States, but a more widespread effort under different environmental conditions is needed. Handling techniques and equipment are also required. We also need to measure the possibility of long-term leaching or other environmental effects.

3. Special reinforcing additives for asphalts. The addition of rubber and other polymers to improve the performance of asphalts has been the subject of considerable research with uncertain results. However, the possibility still exists that useful additives can be found to significantly upgrade asphalt performance. One possibility now under study by a private company is the incorporation into the mix of pelletized carbon black that disperses into the asphalt during the mixing cycle. The resulting mixture is claimed to have superior "toughness" and abrasive resistance.

4. Better prime coats. Many who are willing to eliminate cutbacks as tack coats believe that the present available emulsions do not provide adequate primes. Consequently studies should be conducted both to determine more precisely the conditions under which prime coats are needed and to develop a better priming material, preferably an emulsion.

5. Performance of 2-layered portland cement concrete pavements. These consist of a lower portion made of local materials and less cement and an upper portion of high-grade concrete. One state is now planning to build such an experimental pavement.

GENERAL COMMENT

Throughout the discussions, one thought was repeatedly expressed: In any comparison of cost effectiveness or energy-use effectiveness, the total life of the pavement and the total effects on energy consumption must be considered. We must avoid changes that look good in the short run but result in loss of durability or traffic slowdown and tie-ups that ultimately waste both energy and money.

To assist in this type of evaluation, a careful systems analysis or decision analysis should be made to pinpoint those areas of promising payoff. The energy used in transportation construction in the United States is a relatively small portion of the total energy. Consequently, our efforts will have a minimal effect on the total energy picture. However, as a means of stretching the highway dollar, the energy and materials conservation measures will have a significant impact.

With regard to the future, demands for energy derived from petroleum (gasoline, fuel oil) will likely remain high or increase while existing supplies of petroleum are being depleted. The trend will likely be toward more complete refining by cracking suitable crudes and a consequent decrease of available asphalt. We will then be faced with the need to establish priorities to conserve the available supplies of asphalt for use in the more critical applications, such as use of asphalt in surfaces or for maintenance only.

In contrast to the probable ultimate reduction of asphalt supply because of petroleum depletions, the raw materials for cement manufacture appear plentiful. Exhaustion of specific deposits and quarries will, of course, occur but the basic minerals will always be available somewhere. The problem here will be one of production capacity which, one hopes, will increase as needed.

Accordingly it appears that the highway industry will be faced with the need to make use of hydraulic cements or pozzolanic materials in applications for which asphalts are now used. The needed changes should be controlled by the laws of supply and demand without arbitrary bans or regulations that could unnecessarily create economic and business hardships without accompanying benefits.