# Part III

# SUMMARIES: NATIONAL AND INTERNATIONAL VIEWS

## NATIONAL VIEW

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I have been asked to summarize from a national view this conference of some 50 papers and addresses in just a few minutes. Obviously, I can try and emphasize only a few points.

I think we should be especially impressed by the studies being made in other countries to assist them in establishing models to be used in evaluating highway construction and maintenance policies. Four years ago at Boise we heard about the Kenya road transport cost study, with vehicle operating costs related to such items as road surface types and roughness. At this conference, five separate papers have described parts of the 12 million-dollar research in Brazil to determine relationships between vehicle user costs, roadway design standards, and maintenance policies for low-volume roads. This research has included such items as the monitoring of both paved and unpaved sections to measure roughness, gravel loss, and rutting as affected by traffic, alignment, and other items; vehicle operating cost studies for over 1200 vehicles, with road roughness being found a significant factor; and speed studies as affected by surface types, road roughness, and grades. All of these relationships are being incorporated into a computer-based planning model.

Although not as extensive as the Brazil studies, we have had papers concerning planning of highway investment decisions in developing countries, with consideration of a variety of maintenance policies; a study for Egypt in which various maintenance strategies involving thick or thin overlays and three road classes were analyzed; a study of road roughness in Bolivia and its use in planning road grader operations for maintenance; a paper on the effect of simple maintenance, such as a labor-intensive sand sealing, on vehicle operating costs on St. Vincent in the Eastern Caribbean; and a paper of the planning of a road classification system for Gambia, Africa.

What is the significance of papers such as these for engineers in the United States? In this country we seem to be much less concerned with vehicle operating costs and how they are affected by road surface design or maintenance practices. Extensive studies of this nature were made by Winfrey and others here in Iowa about 40 to 50 years ago, and Claffey reported in NCHRP Report 111 in 1971 that road surface conditions do affect fuel and oil consumption, tire wear, and maintenance. However, in the selection of road surfaces and their design by most local road agencies, be they gravel, surface treatment, or more substantial pavement, the possibility of these variations do not seem to have been considered. Perhaps with the range of surfaces which we have these differences are not great, or perhaps we do not really know what they might be. Certainly these extensive measurements which have now been made merit our detailed study, and perhaps we should be making additional studies ourselves.

These countries have attacked such practical questions as "At what average daily traffic on a gravel road is a surfacing such as a light surface treatment economically justified?" Also, measurements of travel losses and needed gravel replacement are being made in the studies. The results should be pertinent to our aggregate surfaced roads.

The Kenya and Brazil projects and research in other countries should be a great help not only in maintenance but also in design of their road surfaces. In the United States, a systems approach for the design of asphalt and aggregate surfaced roads is given in the paper by McCullough, Roberts, and Pelzner of the University of Texas, Austin Research Engineers, and the U.S. Forest Service. This so-called pavement management system utilizes material, traffic, environmental, and economic considerations in the design, as described. However, it does not use vehicle operating costs directly. It uses design patterned on the AASHTO structural design equations for flexible pavements and PSI's. This procedure can be applied, of course, to an extensive system of roadways, and it has now gone through a trial implementation phase by the Forest Service. Such a system is not easy to establish, I am sure. It is interesting to note the considerable effort needed to introduce this system into actual use. Training sessions have been held in several regions, and refresher meetings are being considered. Such face-to-face instruction seems quite essential to make a system work, and several years' time may be required to establish it fully. It certainly would merit study to see if it might be utilized by other agencies. Again, it might not be easy to intoduce its use into a county without some face-to-face instruction

Now, let's note some of the papers of U.S. origin on other subjects. Emphasis in this country seems to be on soils evaluation and on improvements in stabilization methods and economic surfacing or pavement design. It is interesting to note that in Mr. Millard's keynote address he selected three particular aspects of highway engineering to discuss and the first of these was "soil mechanics as applied to highway engineering." As a retired teacher of soils, this is dear to me, even though he did choose to tell us where things have gone wrong. He was really quite rough in stating that those of us who are, or who were, university professors have failed in instructing those who have gone to foreign lands about the nature of soils in the field and the problems encountered. It just reemphasizes that, after learning a few basics, there is no teacher like experience and we must emphasize an inquiring eye and a desire to get one's hands dirty.

I believe this is really what Mr. Millard said in his concluding paragraph. To quote his last sentence, "The real purpose (of education) is to equip us so that our eyes and ears are open and our minds are ready to gain experience of how the world works and to put this experience to good practical use."

I was somewhat surprised by the frequent mention and widespread use of the CBR as an evaluator in several countries. I have no quarrel with this, and am happy to hear of such common use so that comparisons can be made from one country to another. Also AASHTO T-99 or T-180 (that is so-called Proctor or Modified AASHTO) compaction have widespread use. One paper has shown how SCS soil maps and a correlation of soil series names with CBR can assist in preliminary design of thickness. Another paper points out the potential for a soil data bank.

On stabilization or pavement materials, there are two papers on soil-cement, indicating that this process developed almost 50 years ago is still undergoing study, and there are three papers concerning emulsified asphalt-aggregate mixtures, one being a modification with Portland cement. You may recall emulsion-aggregate mixtures were also discussed at Boise. Reduction in use of cut-back asphalts makes the study of such cold mixes more pertinent today. The design procedures for mixes as developed in Illinois and Mississippi and the information on layer coefficients for an emulsion open graded mix should be of immediate use to some agencies. The discussion Monday evening on light bituminous surfaces was in my opinion one of the best learning experiences of this conference. Sessions of a similar nature should be considered for future conferences.

It is interesting to note that at this conference there are two papers on Portland cement concrete for low-volume roads. The utilization of a local aggregate) on an Indian reservation in North Dakota (about 1/3 coarse aggregate and 2/3 fine aggregate) brought the costs of a 5-1/2-inch slab down to $6.00, plus or minus, per sq. yd. And it was also timely to obtain more information on Portland cement overlays on county roads in Iowa, as this state has been a pioneer in trials of such work. The description of the construction procedures for 6-inch slabs over old asphalt pavements, especially to establish and control grade and thickness of the new slab, should be of value to those planning such work.

I am somewhat surprised that there were not more papers or mention of bridge inspection and inventory. Although such work has been required for all spans on the federal-aid systems, recent legislation has extended this to include off-system bridges also. This means that structures on county roads and those under township jurisdiction are included. The paper by Wade and Larsen of the Illinois DOT recounts the experience in that state. Identification of structures and their degrees of obsolescence may be a help in securing funds for necessary rehabilitation. Other agencies may find the Illinois system, or parts of it, useful.

Apparently, design information on low-water crossings of streams, fords with culverts or low-water bridges is almost nonexistent. Thus, the paper by Coghlan and Davis of the Forest Service should be welcome.

I would judge the paper by Glennon on "Highway Safety Requirements for Low-Volume Roads" to be of great value and one which county engineers might put to immediate use. I have found the county engineers reluctantly accept many of the present design standards because there seems to be no good explanation of how they have been derived and many seem to be merely arbitrary. In the Glennon paper, factual information such as accident data and field observations and probability calculations have been used to study and make design recommendations for such items as the need for speed signs, shoulder and total road widths, curve design and warning signs, stop signs, centerline markings, no passing stripes, and possible or needed removal of roadside obstructions. I believe this is the type of information which was stated to be of great need by both Mr. Manning, speaking for the state interest, and Mr. Schwark, for the county interest, at the Plenary Session. Suggestions are also made for studies which would add further to these types of recommendations. A most useful study would be if accident data could be collected along with a traffic volume category and, if possible, some measure of design quality of the road. Another study would be to measure several traffic characteristics, such as hourly volumes, directional split, vehicle types, speed, etc. Such data would be used to verify some of the assumptions which were made in the safety study.

Low-volume roads in our country are designed, built, and maintained by federal agencies, state DOT's, counties, townships, municipalities, and other miscellaneous agencies or organizations. One of our major problems is how to get the best information concerning low-volume roads to this wide divergence of agencies, especially at the county and municipal level. Certainly conferences such as this are one means of making research results known. However, the written reports are not really adequate for many road agencies such as the counties. This point was made very well by Mr. Kimambo of Tanzania in a discussion at Session 6, which was on the needs for information on low-volume road technology by developing countries, when he said, "Don't just send us the compendiums, as they will only be put on the shelves to gather dust."

As was mentioned for the pavement management system which has been developed for the Forest Service training sessions, where the developers discuss the system with the potential users, have been found as the best means of implementing its use. I would like to also call your attention to the procedures which have been developed in Minnesota for assisting the counties and municipalities in utilizing research findings, as described in the paper by Skok and Lukanen. The Minnesota Local Road Research Board has a major research implementation project, and the engineers who have conducted the research go to small groups of municipal, county and state engineers to give detailed instructions. This method has been used to get the agencies to use surface condition rating systems, measurements of ridability, traffic evaluation, and strength measurements. This scheme has been judged to be highly successful in getting our research results into actual use by agencies concerned with low-volume roads.

I would like to finish these remarks with just a few individual statements gleaned from a variety of the papers.

1. "Observation of pavement performance is still and will be for many years to come, one of the most valuable means by which the local practitioner can gain the necessary design skills." (Dunlop)

2. "Road geotechnical engineering is an art which depends for a large measure for its success upon the exercising of sound judgment; and sound judgment comes from long and tried experience, based on acute observation." (Mitchell, Petzer and van der Walt)

3. "The single most important aspect in the design and construction of a low-volume, low-cost road is the variation in material quality." (Strauss and Hugo)

4. I could quote any of several recommendations of the paper by Hicks and Hatch. Just one is: "Improve construction records to better document the history of each project. A documentation process accessible to the designers would allow analysis of new processes and materials."

Certainly if we can learn lessons such as contained in these single statements, our time has been well spent. I am certain I speak for all of us as I express thanks for this conference to the several agencies that organized it, the committee that set up the program, the individuals that have handled the details, and the persons who have authored and presented the papers.

## INTERNATIONAL VIEW

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Mr. Chairman, ladies and gentlemen: I was supposed to speak on the international viewpoint summary from that angle on the conference but the learned Professor, I think, has preempted everything I wanted to say and I am not sure whether there is anything else left to say after such a brilliant summary of what has transpired for the past three days. However, if you will bear with me for a few minutes I will just present one or two aspects that I think should be looked into.

The Second International Conference on Low-Volume Roads, in my view, has been most successful. The conference has highlighted areas in which developing countries need to focus their attention in their desire to maximize development with limited funds. Low-volume roads constitute the bulk of the roads in these countries and they best serve the immediate and daily needs of the people. I would like to touch on a few of the very many excellent papers that were presented at this conference.

### The Use of Local Materials

Many people clearly demonstrated the need to use local materials in the construction of low-volume roads, if minimum costs are to be achieved. One paper dealt with ways and means of turning local soils, either in their natural state or modified by lime, asphalt, or cement into load-bearing bases and subbases. It is recognized that low-volume roads carry heavy axle loads with quite destructive capabilities. Only bases and subbases of high enough strengths can adequately distribute loads to the subgrades. These subgrades are usually, in the case of low-volume roads, prepared with minimum efforts. Two papers dealt with the needs to understand local materials, at first sight, without resorting to complex and costly laboratory tests. The tools to use were soil surveys and geotechnical data banks.

### The Use of Local Labor

Some papers presented at this conference have touched on this subject. I must caution, however, that we must not let ourselves be carried away with the so-called labor-intensive, labor-based methods which reduce the quality of life in the developing world and dehumanize the people. Any so-called appropriate technology that turns human beings into work horses or seeks to perpetrate underdevelopment by embarking on the construction of jungle trails is best forgotten. Only certain aspects of work in the construction of low-volume roads lend themselves to labor-based methods and only these should be encouraged. For instance, protection of embankments through grassing, turfing, and stone pitching; desilting of culverts and cleaning of blocked drains, and routine pavement maintenance operations such as pothole repairs and patching of distressed pavements with hot or cold mixes, are examples that can be executed by local labor. On the other hand, it would be quite futile to attempt soil-cement stabilization by mixing the soil and cement in head pans, spreading by oxen labor and compacting by the stamping of feet.

### New or Improved Methods

Several papers dealt with recent developments in the use of traditional methods, refinements in existing methods and better utilization of local materials. An interesting paper is the one that dealt with the use of sulphur-treated bamboo in reinforcing concrete and in reinforcing earth. The ideas contained in this paper can be extended to reinforcing walls of traditional houses built of clay or mud in developing countries. The need to provide shelter for the population of the developing countries, at least cost, is a matter that is being urgently considered in these countries. In the same category was a paper that dealt with new efforts at making durable pavements with asphalt emulsions, and with the use of lateritic soils in Thailand's Khorat Plateau. New Zealand's experience in the pavement design and the performance of low-volume roads carries a message that can be explored to the advantage of all developing communities.

### Problems of Maintenance

Maintenance, as you all know, is a big problem to many developing countries. Emphasis in development has been on new construction and insufficient funds are allocated for maintenance. Properly organized, equipped, staffed and efficient road maintenance organizations are the exception rather than the rule. It is important, therefore, to always strive to make any construction as durable as possible, and certainly for more than five years of life. Road improvement by new application of surface dressing or the laying of hard asphaltic concrete overlays should be seen as steps in the stages of development of low-volume roads to those of high levels of service and function. When to maintain and what to do were also well illustrated by papers on a program of bridge inventory, inspection, and rating for a local roads system and the evaluation of the structural adequacy of bituminous pavements in Minnesota.

Some interesting papers dealt with the engineering economics of maintaining and paving of low-volume roads. These are useful tools but the immediate needs of developing countries as far as maintenance of low-volume roads is concerned are simple operational manuals that teach basic maintenance procedures.

I would like to comment on the conference session on developing countries' needs for information on low-volume road technology. I was a panelist at that session. What has come out as the prime need from that session is the necessary data for the basic things. Whereas the developed world has computerized data banks, the developing countries are still groping in the dark for such basic data as runoff coefficient for drainage design, rate of asphalt absorption by local aggregates, and, indeed, the required