Gouvernement du Québec
**Ministère
des Transports**

Laboratoire central

COMPTE-RENDU DE LA 68IEME RÉUNION ANNUELLE DU TRB, JANVIER 1989

Complexe scientifique, 2700, rue Einstein, Sainte-Foy, QC G1P 3W8 Tél.: (418) 643-3178

4/0096

Activité 820 820

COMPTE-RENDU DE LA 68IEME RÉUNION ANNUELLE DU TRB, JANVIER 1989

Préparé par: Richard Langlois, ing.
Chef - Division Matériaux
Ministère des Transports
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C.C. Centre de documentation (2)
Service des Relations Ministérielles
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Ted Jiona
André Arès
Lionel Dufour
Yvan Lavoie
M. Bonneau, Ponts et Chaussées en France

Sainte-Foy, le 28 février 1989.

COMPTE-RENDU DE LA 69ieme RÉUNION

ANNUELLE DU TRB, JANVIER 1989

1.0 IDENTIFICATION DES PARTICIPANTS

1.1 Nom : Richard Langlois

1.2 Fonction : Ingénieur
Chef -Division Granulats et Revêtement Bitumineux

2.0 DESCRIPTION DES VOYAGES

2.1	Endroit :	Washington
2.2	Durée :	21 au 27 janvier 1989
2.3	Autorisation:	CT 89-C-01
2.4	Raison du voyage :	Participer au TRB et à la réunion du SHRP à titre de coordonnateur Québécois du SHRP et membre du groupe de coordination de la recherche en infrastructure des transports.

3.0 CARACTERISTIQUES DES REUNION

3.1 Type de réunion : Nationale à caractère international

3.2 Nom de l'organisme responsable: Transportation Research Board et Strategic Highway Research Program

3.3 Contenu des réunions:

3.3.1 Liste des thèmes abordés: Elle est présentée en annexe A et elle constitue également la liste des activités

3.3.2 Résumé des conférences et des discussions.

Les sessions techniques ont été des plus intéressantes et très diversifiées: Les auteurs venaient de différents milieux, de gouvernements, de municipalités, d'universités et de diverses entreprises privées.

Les principaux faits techniques découlant des diverses rencontres, discussions et présentations techniques se résument ainsi:

A) **RÉSUMÉ DE LA RÉUNION DES COORDONNATEURS SHRP 22 JANVIER 1989**

Les points suivants résument les principales informations transmisses lors des exposés et des discussions

1- Les sections SPS d'entretien et de recyclage seront construite surtout en 1990. Seules quelques sections seront faites à la fin de l'été ou à l'automne 89.

2- Présentement, 961 sections GPS ont été examinées, dont 738 ont été conservées pour études.

3- Le rôle des ETG (expert task group) est de peser le pour et le contre des propositions de recherche, en indiquer les points à améliorer, et de les classer par ordre de qualification.

4- Le guide d'échantillonnage et de carottage sera disponible en février. Au Canada chaque province devra effectuer cette opération selon le guide et les directives d'un responsable de la firme qui a le contrat de collecte des données dans la région atlantique nord.

5- Un formulaire détaillé de collecte des données de trafic sur les sections GPS de SHRP a été distribué pour remettre à nos services de la circulation.

6- Un atelier se tiendra le 27 février prochain pour établir les modalités finales des sections SPS d'entretien et de recyclage.

7- En février chaque état ou province recevra une liste des sections GPS près desquelles des sections SPS d'entretien et de recyclage sont désirées.

8- Pour la réalisation de l'obturation des fissures et des coulis de scellement, les contracteurs devront être approuvés par SHRP. Pour les traitements de surface, l'état ou SHRP peutapprouver les contracteurs.

9- D'ici un an, 30 à 50 % des mesures au FWD plus de 50% des photos par l'appareil PASCO, 30 à 50% des profils, et 40 à 50% de l'échantillonnage et du carottage seront réalisés. Les données historiques des sections GPS auront été complètement collectées.

10- L'appareil ALF (accelerated loading facility) de FHWA fera l'étude SHRP sur l'influence de la pression des pneus sur l'orniérage des bétons bitumineux, ainsi que la conception de mélanges résistant à l'orniérage.

11- Le test d'échantillonnage a montré que les "tests pit" sont supérieurs au carottage. Pour les réaliser, la province ou l'état doit fournir: 1 Backo, 1 loader, 1 camion, 1 génératrice, 2 hommes pour 1 jour, 1 marteau compresseur, une scie à pavage.

12- L'étude sur les raffineries (60 US, 12 Canada) a obtenu un fort taux de reponse, soit 55 sur 72 et cela représente 85% de la production.

13- Sur les huit (8) bitumes choisis pour le corps principal de l'étude SHRP, 2 sont canadiens, soit le Loyd ministère et le Red Water. Parmi les 22 autres choisis, 2 autres sont canadiens.

14. Les bitumes échantillonnés sont le grade le plus commun fabriqué par la raffinerie et le grade plus mou suivant. Le bitume le plus mou échantillonné est un 200-300 de pénétration.

B) RÉSUMÉ DES SESSIONS ET COMITÉS DU TRB

1. D.A. Anderson recommande l'essai de flexion simple pour évaluer les bitumes aux températures inférieures à 25°C. De plus il a trouvé de bonne corrélation entre cet essai et la pénétration à 1,2°C ainsi qu'avec la température de fragilité Fraas.

2. En Louisianne un béton bitumineux clouté avec 5,4 kg/m^2 de pierre donne au point de vue résistance à la glissance à peu près le même rendement qu'un enrobé ouvert à friction élevée. De plus dans cet état, la pierre de classe I doit avoir un CPA supérieur à 37, alors que pour les classes II, III et IV, le CPA (coefficient de polissage accéléré) est respectivement compris entre 31 et 36, 25 et 34, 22 et 25.

3. Selon L. Greene, les couches d'enrobés poreux à friction élevée ont une vie moyenne de 12 ans sur les aéroports.

4. Selon Jon EPPS, l'essai Vialit est très valable pour évaluer les traitements de surface car il a une bonne corrélation avec la performance sur la route.

5. Dans un mélange bitumineux, selon Khedaywi il faut avoir le bon granulat fin pour obtenir une bonne résistance à la déformation. Plus le fin est rugueux, plus il doit être grossier pour donner avec le gros granulat le meilleur emboîtement et aussi la meilleure résistance à la déformation.

Il calcule la surface moyenne des particules de granulat par l'équation suivante:

$$AS = \frac{1}{2} \quad d \left(d + \frac{l}{k} \sin^{-1} k\right)$$

ou: AS = surface des particules en cm^2

l, m, s, = longue, medium et courte dimension de la particule

$$d = \frac{m + s}{2} \qquad \text{et } k = \left(\frac{l^2 + d^2}{l}\right)^{\frac{1}{2}}$$

6- Une étude du Texas A + M montre que la méthode de compactage en laboratoire qui se rapproche le plus du compactage sur la route est le compacteur giratoire suivi par le compacteur HVEEM. Le compacteur Marshall avec base fixe et sans angle du marteau est la méthode étudiée qui s'éloigne le plus de compactage routier.

7- En utilisant le recyclage à froid avec une émulsion en Israel, une économie de 32 % ($ 31.40 vs $ 46.40) a été réalisée par rapport au béton bitumineux conventionnel. De plus les résultats préliminaires (1 an) laissent présager une très bonne performance.

8- Le mélange bitumineux Verglimit est susceptible aux dégradations par l'eau. Le mélange Plus Ride est très résistant a basse température mais serait susceptible à l'orniérage.

9- L'AASHTO a une spécification qui limite l'entreposage des mélanges bitumineux dans les silos à 16 heures pour les mélanges denses et à 2 heures pour les mélanges ouverts.

10- A la réunion de l'AAPT, les représentants des états américains se réunissent un après midi pour discuter et échanger sur leurs problèmes en béton bitumineux.

11- Un produit appelé Salviacim de Alyan corporation inc., constitué d'un mélange bitumineux ouvert imprégné d'un coulis de ciment, s'avère un revêtement résistant à l'orniérage, aux produits pétroliers et chimiques. Son coût pour une épaisseur de 63 mm est de $9.50 à $12.00.

12- Une étude de différents additifs ou polymères dans les mélanges bitumineux donne la classification suivante par ordre de résistance à l'ornièrage et autres propriétés de performance:

- Mélange avec polyéthylène
- Mélange avec SBS/soufre/catalyseur
- Mélange avec SB/chaux/soufre/catalyseur
- Mélange avec Trinidad lake asphalt
- Mélange avec Carbon black
- Mélange avec PCP (polychloropropyline)
- Mélange avec fibre de polyester.

13- L'auto-obturation ou le recollage des fissures dépendrait des propriétés chimiques du bitume et varie donc d'un bitume à l'autre. Il faut de la recherche supplémentaire pour identifier le mécanisme qui contrôle le recollage chimique du bitume et ainsi pouvoir modifier les liants pour augmenter leur propriété de recollage.

14- La résistance à la déformation, selon Salter et Al-Shakarchi, est augmentée par des granulats concassés, et par l'ajout d'EVA (éthylène vinyl acetate).

15- Un programme ACMODAS 3 fournit une méthode de prédiction de la performance de la vie des ornières à l'humidité des revêtements bitumineux. Pour cela, il fait appel aux modules résilients secs et humides des mélanges bitumineux.

16- Une étude a évalué 7 méthodes d'essais pour mesurer la forme et la texture de surface des granulats. Ces essais sont:

- L'essai de National Crushed Stone Association (NCSA)
- L'essai d'indice de forme et de texture des particules de granulat (ASTM-D3398)
- L'indice de temps de Rex et Peck
- L'essai du rapport de vides de Western Technologies
- L'essai de rapport de portance de la Floride
- L'essai de cisaillement direct

- L'essai de rugosité spécifique par le volume de remplissage

Parmi ces essais, les meilleurs résultats ont été obtenus avec celui de la NCSA, l'indice Rex et Peck et la rugosité spécifique.

17- Le sel selon Crumpton et Al aggrave la réaction alkali-granulat, le problème de fissure-D et l'explosion des dalles de pavage en gardant le béton interne mouillé plus longtemps, car quand le béton et les granulats calcaires demeurent humides la durée de gonflement de la solution saline dans le granulat augmente, et cela procure plus de temps pour amorcer les autres réactions.

18- L'analyse par rayon X en Iowa des granulats de carbonate est une méthode effective pour prédire leur performance dans les bétons de ciment.

19- Selon Gayle King, dans un avenir rapproché on pourra distiller à la raffinerie un bitume aux propriétés désirées.

20- L'utilisation d'un détecteur spectrophotométrique à photodiode ajoute à l'information chimique sur les bitumes obtenues par le HP-GPC.

21- Glover et Al ont montré que le TFOT et le RTFO ont un effet similaire sur la pénétration et les viscosités à 60 et 135°C.

22- La technique des boulettes de K Br pour l'analyse infrarouge a été adaptée pour les matériaux bitumineux et cette procédure est hautement reproductible.

23- La teneur en asphaltènes dans les bitumes est plus élevée si l'on fait l'essai avec du n-Hexane au lieu du n-Heptane. De plus les résultats au HPLC correspondent très bien avec ceux de la méthode Corbett de chromatographie liquide.

24- Selon Noureldin et Al, un bitume dont la pénétration et la viscosité originale était de 65 et 1890, a obtenu une pénétration et une viscosité après 10 ans de 28 et 20888, soit une diminution de 57% pour la pénétration et une augmentation par un facteur de 11 pour la viscosité. Il recommande l'utilisation du HP-GPC pour le choix de la qualité et de la quantité de l'agent de recyclage pour rajeunir des vieux bétons bitumineux.

25- Au comité A2 Fo2 on a identifié comme prioritaire la recherche sur les mélanges bitumineux avec grosses pierres.

26- Selon Sherocman, la résistance des fondations n'influence pas la compacité des couches de béton bitumineux et cela est démontré par deux rapports d'étude.

27- Afin d'obtenir une pose uniforme des mélanges bitumineux il existe un "Shutre buggy" de 30 tonnes qui agit entre les camions et la finisseuse. Cet outillage améliore grandement la qualité des couches de béton bitumineux, mais coûte cher: $ 70000.00 US.

28- Dans les mélanges bitumineux où il y a ségrégation, la force de tension est réduite de 20%.

29- Un système expert SEG a été créé par Elton pour trouver la cause de la ségrégation dans les revêtements bitumineux.

30- Les nucléodensimètres donnent une mesure qui est influencée par le type de granulat et, par conséquent, ils doivent être calibrés au moyen d'une régression avec au moins 10 carottes (Tahmoressi).

31- Selon Linden, chaque % de vide supérieur à 7% dans les revêtements bitumineux diminue leur résistance à la fatique de 20% et décroît la pénétration de 6%. En moyenne, le revêtement bitumineux a une année ou 10% de perte de vie pour chaque accroissement du % vide au delà de 6%. Donc la norme compacité des revêtements bitumineux devrait être de 92% minimum (aucun résultat en bas) et de 97% maximum (pour éviter le ressuage et l'ornériage).

32- Un bon module résilient est obtenu avec une teneur en filler de 3% : plus basse le module est diminué, tandis que plus haute, le module est peu augmenté.

33- Jimenez a créé un essai de désenrobage qui s'apparente au processus qui se passe en chantier. Il fait des cycles de variation de la pression d'eau de 34 à 207 kPa.

34- Selon Maupin, la tension minimale après trempage doit être de 275 kpa et le rapport minimal des contraintes humides sur sèches, de 30%. De plus il conseille d'utiliser des carottes recompactées pour estimer la force originale du revêtement.

35- Selon Kiggundu, le succès ou la valeur des méthodes d'évaluation du désenrobage sont établies à partir de leur corrélation avec un comportement routier. Il a estimé la valeur des méthodes suivantes:

- NCHRP 246 (Lottman) 76 % si TSR = 80 %
  66 % si TSR = 70 %

- NCHRP 247 Tunnicliff - Root 66.7 %

- AASHTO T 165 47 %

- Boiling test 10 minutes 58 %

- Nevada methode dynamique 36 %

36- Tant le bitume que les asphaltènes ont plus d'affinité pour le calcaire que le grès. L'absorption du bitume est fonction du degré d'oxydation, du granulat dans lequel il est absorbé, et de la teneur en humidité de surface du granulat. (Curtis et Al).

37- La durée de chauffage du bitume avec l'additif peut diminuer la teneur en additif. L'essai ASTM D2073 a été modifié pour mesurer directement la quantité d'additif de type amine présente dans le bitume (Tarrer et Al).

38- Les traitements de surface en Australie ont une durée de 10 à 12 ans. Ils ont une machine pour enrober et écrèter les granulats avant épandage.

39- Chollar et Al ont trouvé que les tambours sécheur - malaxeur oxydaient le bitume un peu plus que les usines à fournée.

40- Une étude par Stroup - Gardiner et Al a montré que l'essai d'extraction du bitume par la méthode centrifuge (ASTM D2172) avait un écart type de 0,21 intra laboratoire et inter laboratoire, ce qui est équivalent a la méthode nucléaire ASTM D4125 qui est de 0,23.

3.3.3 Documentation recueillie

L'annexe B fournit les titres des exposés, des conférences et des documents techniques recueillis en plus de ceux marqués d'un astérisque * en annexe A avec la liste des thèmes abordés. 50 textes techniques ont été apportés dont 26 gratuits et 34 achetés au coût de $ 3.00 us.

3.4 Liste des personnes assistant aux réunions

Plus de 1500 personnes assistaient aux différentes réunions et aucune liste n'était disponible. Seule la liste des conférenciers était disponible et elle est présentée en annexe C.

4.0 NATURE DE MA PARTICIPATION

1. Sessions techniques et comités

J'ai posé des questions ou fait des commentaires sur la plupart des conférences et ateliers des différents comités où j'ai assisté

2. Réunion des coordonnateurs SHRP

Dimanche, de 8h30 à 17h00, à titre de coordonnateur québécois du SHRP, j'ai participé à cette réunion. J'y ai posé plusieurs questions afin d'obtenir des éclaircissements entre autres sur les sections SPS. L'agenda de la réunion est présenté en annexe D. Le résumé est donné à l'item 3.3.2.

3. Souper de la francophonie

J'ai organisé un souper le jeudi soir pour permettre aux francophones assistants au TRB de se rencontrer et d'échanger: 2 français et 1 québécois y ont participé. Cela a permis des échanges fructueuses et la création de liens amicaux avec nos collègues de France.

4. Contacts et personnes rencontrés.

La liste est donnée à l'annexe E.

5.0 POINTS D'INTÉRÊT POUR LE MTQ

Tous les faits techniques énumérés dans le résumé des conférences et des discussions sont d'un intérêt pour le MTQ. Les points suivants sont d'un intérêt peut-être plus marqué.

1. Le MTQ doit prévoir le personnel et l'équipement pour faire le carottage et l'échantillonnage des sections SHRP en 1989 - 90.

2. Le MTQ doit prévoir le personnel et l'appareillage pour collecter les données de trafic sur les sections SHRP en 1989-91 selon le guide donné à l'annexe F.

3. Pour l'atelier du 27 février 1989, le MTQ devrait déléguer 2 personnes (1 de la direction de l'Entretien et le coordonnateur SHRP du Québec) afin de l'aider à concevoir les sections SPS sur l'entretien et la réhabilitation des revêtements.

4. Tout comme la Louisianne, les granulats pour les revêtements routiers du Québec devraient avoir une exigence sur le CPA (coefficient de polissage accéléré).

5. Le MTQ devrait utiliser le recyclage à froid pour la réhabilitation de certaines chaussées.

6. Le MTQ devrait procurer au Laboratoire Central la presse de compactage giratoire car c'est cet appareil qui compacte de la façon la plus analogue au chantier.

7. Le MTQ devrait améliorer sa norme sur la compacité des revêtements bitumineux: aucun résultat inférieur à 92% ne devrait être accepté sans pénalité.

8. Le Laboratoire Central devrait se fabriquer l'appareil Jimenez de désenrobage (12000,00$ US estimé par Jimenez lui-même, et cela comprend l'achat de toutes les pièces et contrôles électroniques requis).

6.0 AUTRES INFORMATIONS

En résumé, cette réunion a été l'objet d'échanges très fructueux pour tous les participants grâce aux très bonnes dispositions matérielles mises à leur service. La prochaine réunion annuelle se tiendra à Washington en janvier 1989 et elle méritera elle aussi que le Québec y délégué des représentants, non seulement pour acquérir de nouvelles connaissances, mais aussi pour faire profiter aux autres ses propres connaissances. De plus, les personnes déléguées devraient avoir une bonne connaissance de l'anglais, des connaissances techniques importantes et une aisance à parler en public afin d'y faire valoir le point de vue du Québec et de faire bénéficier les autres des techniques développées au Québec. Le TRB est le congrès où les principales recherches en Amérique dans le domaine des transports et des infrastructures du transport sont présentés. Il serait donc très important que les différents secteurs soient couverts par un spécialiste dans le domaine. Pour ce faire, le MTQ devrait déléguer à chaque année au TRB les spécialistes suivants:

	Domaine	Service concerné
1.	Béton Bitumineux	Laboratoire Central
2.	Béton Ciment	Laboratoire Central
3.	Mécanique des chaussées	Sols et Chaussées
4.	Collectes de données	Relevés Techniques

5. Transport

6. Programme SHRP — Coordonateur québécois

7. Equipement et Opérations — Direction des Opérations

De plus, j'ai distribué des "kit" d'information sur le Québec à 8 personnes et elles ont grandement apprécié le geste en mentionnant que cela les inciterait sûrement à visiter le Québec.

Sainte-Foy, le 1er mars 1989.

ANNEXE A

LISTE DES THÈMES ABORDÉS

LISTE DES ACTIVITÉS

ACTIVITÉS SUIVIES PAR R. LANGLOIS AU TRB 1989.

Dimanche 22 janvier 89 - 8h 30 à 17h 30

Réunions des coordonnateurs du programme SHRP

Lundi 23 janvier 89

9 h 00 à 10 h 30	Sessions No 8: "Programme de recherche stratégique sur les routes".
10 h 30 à 12 h 00	Session No 7: "Les couches de surface à friction élevée".
14 h 00 à 17 h 30	Comité A2D01 sur les caractéristiques des matériaux bitumineux.
20 h 00 à 22 h 30	Session No 53: "Mélange bitumineux: granulats, compaction et évaluation en chantier.

Mardi 24 janvier 89

9 h 00 à 12 h 00	Comité A2D03 sur les caractéristiques des mélanges bitume-granulats pour rencontrer les exigences de surface.
14 h 00 à 16 h 00	Session No 99:" Mélanges bitumineux: effets de l'humidité, de la température et du gel-dégel".
16 h 00 à 17 h 30	Comité A2B04 sur la réhabilitation des chaussées.
20 h 00 à 22 h 00	Session No 123: "Innovations dans les essais sur les granulats".

Mercredi 25 janvier 89

9 h 00 à 12 h 00	Session No 147: "Chimie des bitumes" Note: le titre dans le programme a été mêlé avec la session No 219.
14 h 30 à 17 h 30	Comité A2FO2 sur la construction et la réhabilitation des chaussées flexibles".
20 h 00 à 22 h 30	Session No 193: "Construction de chaussées flexibles.

Jeudi 26 janvier 89

9 h 00 à 12 h 00	Session No 204: "Performance des mélanges bitumineux".
14 h 00 à 17 h 00	Session No 219 "Le bitume dans les mélanges et les chaussées". Note: Le titre dans le programme a été mêlé avec la session No 147.

* Texte rapporté

Sessions

7 Monday, 9:00 a.m., Sheraton (North Cotillion)
SURFACE FRICTION COURSES
Anne Stonex, Neyer, Tiseo & Hindo Ltd., presiding
Sponsored by Committee on Characteristics of Bituminous-Aggregate Combinations to Meet Surface Requirements

* **Enhancing the Bond of Emulsion-Based Seal Coats with Antistripping Agents** *880016* Ali A. Selim, South Dakota State University
* **Predicting Frictional Characteristics of Seal Coat Pavement Surfaces from Laboratory Tests** *880451* A. H. Meyer, D. W. Fowler, Mohamed-Assem U Abdul-Malak, University of Texas at Austin
* **Eleven Years' Performance of 18 Bituminous Test Sections on a Major Urban Freeway** *880379* K. K. Tam, R. Raciborski, D. F. Lynch, Ontario Ministry of Transportation, Canada

Louisiana Frictional Surfaces, Harold R. Paul, Louisiana Transportation Research Center

Air Force Experience with Porous Friction Surfaces, James L. Greene, U.S. Department of Defense

An Experimental Project for Evaluating Chip Seals, Jon A Epps, University of Nevada, Reno

TAPE

8 Monday, 9:00 a.m., Sheraton (South Cotillion)
STRATEGIC HIGHWAY RESEARCH PROGRAM
John R. Tabb, Mississippi State Highway Department, presiding

SHRP—The First Year, Damian J. Kulash, Strategic Highway Research Program

Asphalt Materials Reference Library, James S Moulthrop, University of Texas, Austin

Asphalt Binder Research, J. Claine Petersen, Western Research Institute

General Pavement Studies, Richard C. Ingberg, Strategic Highway Research Program; James E Nichols, Austin Research Engineers, Inc

Innovations in Work-Zone Safety Systems, Jerry L Graham, Graham–Migletz Enterprises, Inc

Performance History of Field Cathodic Protection Installations in the United States and Canada, Jack Snyder, M. Ken Han, Battelle Columbus Division; Philip Simon, Norton Corrosion Engineers

International Cooperation Activities, Ian N. Reeves, Main Roads Department, Queensland, Australia

53 Monday, 8:00 p.m., Sheraton (North Cotillion)
ASPHALT MIXTURES: AGGREGATES, COMPACTION, AND FIELD EVALUATION

Ronald L. Terrel, Terrel Research, presiding
Sponsored by Committee on Characteristics of Bituminous Paving Mixtures to Meet Structural Requirements

* **Aggregate Rugosity and Size Effect on Bituminous Mixes** *880008* Taisir S. Khedaywi, University of Science and Technology, Jordan; Egons Tons, University of Michigan
Some Studies on the Degradation of Dense Aggregate Gradings *880009* B. Balasubramanyam, S.V. University College of Engineering, India; Mowli P. Pratapa, S.V. University College of Engineering, India
* **Evaluation of Laboratory Compaction Devices Based on Ability to Produce Mixtures with Engineering Properties Similar to Those Produced in the Field** *880492* Alberto Consuegra, Texas A&M University System; Dallas N. Little, Texas A&M University System; Harold V. Quintus, Brent Rauhut Engineering, Inc.
* **Performance of a Full-Scale Pavement Using Cold Recycled Asphalt Mixture** *880316* Ehud Cohen, Yariv Civil Engineering and Surveying, Israel; Arieh Sidess, Rafael Armament Development Authority, Israel; Gabriel Zoltan, Yariv Civil Engineering and Surveying, Israel
* **An Evaluation of Effects of Deicing Additives on Properties of Asphalt Mixtures** *880308* Walla S. Mogawer, University of Rhode Island; Kevin D. Stuart, Federal Highway Administration; K. Wayne Lee, University of Rhode Island

99 Tuesday, 2:00 p.m., Sheraton (Dover)
ASPHALT MIXTURES: MOISTURE, TEMPERATURE, AND FREEZE-THAW EFFECTS

Benjamin Collucci, University of Puerto Rico, Mayaguez, presiding
Sponsored by Committee on Characteristics of Bituminous Paving Mixtures to Meet Structural Requirements

* **Evaluation of Healing in Asphalt Concrete by Means of the Theory of Nonlinear Viscoelasticity** *880283* Youngsoo R. Kim, Texas A&M University System; Dallas N. Little, Texas A&M University System
* **Development of Fracture Criterion for Asphalt Mixes at Low Temperatures** *880229* Raj Dongre, M. G. Sharma, D. A. Anderson, Pennsylvania State University
* **Effects of Ambient Temperature and Thermal Cycling on the Creep of Bituminous Pavement Materials** *880052* R. J. Salter, University of Bradford, England; M. Y. O. Al-Shakarchi, University of Bradford, England
Properties of Asphalt Oil Shale Ash Bituminous Mixtures Under Freezing and Thawing Conditions *880024* Hashem Al-Massaied, Taisir S. Khedaywi, Mohammed M. Smadi, University of Science and Technology, Jordan
* **Prediction of the Effects of Moisture on Wheelpath Rutting in Asphalt Concrete Surfacing** *880116* Robert P. Lottman, University of Idaho; Douglas J. Frith, Austin Research Engineers, Inc.

123 Tuesday, 8:00 p.m., Sheraton (Annapolis)
INNOVATIONS IN AGGREGATE TESTING
Vernon J. Marks, Iowa Department of Transportation, presiding
Sponsored by Committee on Mineral Aggregates

* **Laboratory Evaluation of Shape and Surface Texture of Fine Aggregate for Asphalt Concrete** *880256* W. R. Meier, Jr., Western Technologies, Inc.; Edward J. Elnicky, Western Technologies, Inc.
Aggregate Testing for Construction of Arrester Bed *880320* M. C. Wang, Pennsylvania State University
Determining Clay Minerals in Basalt Aggregates *880019* Ted Vinson, Oregon State University; Tom Szymoniak, CH_2M Hill
* **Salt Weathering of Limestone Aggregate and Concrete Without Freeze-Thaw** *880249* Carl F. Crumpton, Topeka, Kansas; Barbara J. Smith, Kansas Department of Transportation; G. P. Jayaprakash, Transportation Research Board
* **Evaluation of Carbonate Aggregate Using X-Ray Analysis** *880172* Wendell Dubberke, Iowa Department of Transportation; Vernon J. Marks, Iowa Department of Transportation

147 Wednesday, 9:00 a.m., Sheraton (Wilmington)
ASPHALT IN MIXTURES AND IN PAVEMENTS
Robert P. Lottman, University of Idaho, presiding
Sponsored by Committee on Characteristics of Bituminous Materials

* **Use of a Multiwavelength UV-Vis HP-GPC to Give a 3D View of Bituminous Materials** *880348* Joan A. S. Pribanic, Montana State University; Marc Emmelin, Centre de Recherche Elf Solaize; Gayle N. King, Elf Asphalt, Inc. Laboratory
* **A Potassium Bromide Pellet Procedure for the Analysis of Asphalts Using FT-IR** *880421* Charles J. Glover, R. R. Davison, S. M. Ghoreishi, J. A. Bullin, Texas A&M University System
* **Rapid Method for the Chemical Analysis of Asphalt Cement: Quantitative Determination of the Naphthene Aromatic and Polar Aromatic Fractions Using HPLC** *880119* S. W. Bishara, Ernie Wilkins, Kansas Department of Transportation
* **Variations in Molecular Size Distribution of Virgin and Recycled Asphalt Binders Associated with Aging** *880271* A. Samy Noureldin, Indiana Department of Highways, Leonard E. Wood, Purdue University

193 Wednesday, 8:00 p.m., Sheraton (Dover) ASPHALT PAVEMENT CONSTRUCTION

Dale S. Decker, Chevron USA Inc., presiding
Sponsored by Committee on Flexible Pavement Construction and Rehabilitation

* **Investigation of Segregation of Asphalt Mixtures in State of Georgia** *880306* E. R. Brown, Auburn University; Ronald Collins, Georgia Department of Transportation; J. R. Brownfield, CH2M Hill
* **Expert System for Diagnosing Hot Mix Asphalt Segregation** *880091* David J. Elton, Auburn University
Evaluation of a Thin Lift Nuclear Density Gauge *880210* Thomas W. Kennedy, Maghsoud Tahmoressi, Mansour Solaimanian, University of Texas, Austin
* **The Effect of Compaction on Asphalt Concrete Performance** *880178* Robert N. Linden, Linden Engineering; Joe P. Mahoney, University of Washington; Newton C. Jackson, Washington State Department of Transportation
* **Effect of Field Control of Filler Content and Compaction Effort on Asphalt Mix Properties** *880056* Bassam A. Anani, King Saud University, Saudi Arabia; Fahd Balghunaim, King Saud University, Saudi Arabia; Saleh Al-Swailmi, Municipality of Riyadh, Saudia Arabia

204 Thursday, 9:00 a.m., Sheraton (Dover) PERFORMANCE OF ASPHALT MIXTURES

N. Paul Khosla, North Carolina State University, presiding
Sponsored by Committee on Characteristics of Nonbituminous Components of Bituminous Paving Mixtures

* **A Field Control Test for Debonding of Asphaltic Concrete** *880084* Rudolf A. Jimenez, University of Arizona
Moisture Susceptibility Behavior of Asphalt Concrete and Emulsified Asphalt Mixes Using the Freeze-Thaw Pedestal Test *880055* Pablo Esteban Bolzan, LEMIT, Argentina
* **Assessment of Stripped Asphalt Pavement** *880323* G. W. Maupin, Jr., Virginia Transportation Research Council
Effect of Coal Contaminated Aggregate on Asphaltic Concrete Pavement Performance *880025* Vishnu Diyaljee, Alberta Transportation and Utilities, Canada
* **The Success/Failure of Methods Used to Predict the Stripping Propensity in the Performance of Bituminous Pavement Mixtures** *880238* Badru M. Kiggundu, Auburn University; Freddy L. Roberts, Auburn University
Required Number of Specimens for Moisture Susceptibility Testing *880026* Kwang Woo Kim, James L. Burati, Jr., Serji N. Amirkhanian, Clemson University

219 Thursday, 2:00 p.m., Sheraton (Dover)

ASPHALT CHEMISTRY

Vytautas P. Puzinauskas, The Asphalt Institute, presiding

Sponsored by Committee on Characteristics of Bituminous Materials

Absorption of AC-20 and Oxidized Asphalts on Aggregate Surfaces *880336* Christine W. Curtis, Auburn University; Douglas J. Clapp, Auburn University

Detection of Amine-Based Antistripping Additives in Asphalt Cement *880239* Hyon H. Yoon, Badru M. Kiggundu, Arthur R. Tarrer, Freddy L. Roberts, Auburn University

Field Trials of a Lead-Based Asphalt Antioxidant *880096* John W. H. Oliver, Australian Road Research Board, Australia

Changes Occurring with Asphalts in Drum Dryer Mixing Operations *880219* Brian H. Chollar, Federal Highway Administration; Kimberly T. Tran, Pandalai Coatings Company; Joseph A. Zenewitz, Federal Highway Administration; Dave Anderson, Pandalai Coatings Company

Precision of Methods for Determining Asphalt Cement Content *880286* Mary Stroup-Gardiner, Dave E. Newcomb, Jon A. Epps, University of Nevada, Reno

TRB COMMITTEE A2D03 - AGENDA
9 AM, Tuesday, Jan. 24, 1989
Warren Room - Sheraton Washington Hotel

Scope of the Committee: This committee will be responsible for identification of special properties needed by the surface of bituminous pavements and for the selection of proportioning of materials to achieve these properties. The committee will also be concerned with the changes that occur in these properties due to a change in the bituminous paving materials over a period of time (durability). Among the specific properties of the surface to be considered are: riding comfort, frictional characteristics (see A2D03 minutes 1986, Section 3.3.4), tire and pavement wear, raveling, appearance, light reflection and such environmental properties as noise. In addition, bonding to an underlying surface will be considered by the committee.

I. Introduction of Members and Guests
  A. Attendance sheets - circulated
  B. Members not present
    Sabir Dahir - in Jordan - Univ. of Jordan/Amman
    Jim Gentile - death in January
    Vaughn Marker - out of the country
    Rod Monroe - Iowa - lack of travel funds

II. Acceptance of 1988 Minutes (Mailed 2/3/88)
  A copy sent out Dec. 7, 1988 to members for review

III. TRB Announcements
  A. Bill Gunderman, Engr. of Materials & Construction
  B. Len Wood, Chairperson - A2D00 - Bituminous Section
  C. A2B07 - Surface Properties - Vehicle Interaction John Henry, Chair
    (814-863-1888)

IV. Old Business - Associations
  A. AASHTO SubCommittee on Materials
    Comm. 2A Emulsions - Phil McIntyre (NH) nothing
    Comm. 2C Bituminous Aggregate Mixtures
    Comm. 5A Surface Friction - Jim Gehler (IL)

  B. AAPT (Association of Asphalt Technologists)
    1989 Annual Meeting - Feb. 20-22 at Opryland Hotel, Nashville, Tenn.
    Pre-registration fees, $110 members, $135 non-members, $20 more after 2/10.
    Symposium - "Pavement Performance Framework for Success" (Jim & Len).
    Secy. - Gene Skok - 1404 Concordia Ave., St.Paul, Mn (Tel. 612-642-1350)

  C. CTAA (Canadian Technical Asphalt Association)similar to AAPT for Canadians.
    1988 Nov. 13-16 Meeting held in Calgary, Alberta.
    Secy. - R. Noble, P.O.Box 1387/CP 1387, Victoria, B.C. V8W2W3
      (Tel.
      Annual dues - $40 Canadian - includes copy of annual papers.
    1989 Annual Meeting, Nov. , Halifax, N.S.

  D. ASTM (American Society for Testing and Materials) - D-4 & E-17
    Dec. 4-9, 1988 Meeting in Phoenix, AZ.
    June 27-30, 1989 St. Louis, MO.
    Dec. 5-8, 1989 Orland, FL.
    Address: 1916 Race St., Philadelphia, PA 19103 (Tel. 215-299-5400)

  E. NCHRP - Dr. Robert Reilly, Director, o/o TRB, 2101 Constitution Ave., N.W.
    Washington, D.C. 20418 (Tel. 202-334-2934)
    Dec. 1988 Announcement shows 9 projects for $2,870,000.
    Includes 1-28, $500,000 for Establishment of Structural Inputs to
    the AASHTO Flexible Pavement Design Equation.

Fin 1990 NCHRP - 14 - 8 >7500 JMA = Traffic
Design Chip Seal [illegible]

F. RTAC (Roads & Transportation Association of Canada)
1988 Meeting in Halifax, Nova Scotia
1989 Meeting in Calgary Convention Center, Calgary, Alberta
RTAC - 1765 St. Laurent Blvd., Ottawa, KIG-3V4 (Tel. 613-521-4052)

G. Other Associations - Business

V. Current-Past Year's Business

A. 1989 Session 7, Jan. 21, 9 AM, No. Cotillion Room, Anne Stonex Presiding

1. "Improving Frictional Characteristics of Emulsion-Based Seal Coats with Anti-Stripping Agents" #88-0016 A Selim.

2. "Predicting Frictional Characteristics of Seal Coat Pavement Surfaces from Laboratory Tests" #880451 A. Meyer et al.

3. "Eleven Years Performance of 18 Bituminous Test Sections on a Major Urban Freeway" #880379 K. Tam et al.

4. "Louisiana Frictional Surfaces" H. Paul, La.

5. "U. S. Air Force Experience with Porous Friction Surfaces" J. Green

6. "An Experimental Project for Evaluating Chip Seals" J. Epps.

B. "Effects of Bituminous Mix Design on Initial Pavement Surface Friction" by D. Colony - Univ. of Toledo was not accepted - sent back to author for consideration of revisions for 1990 session.

VI. New Business

A. Discussion - objectives for A2D03 in the future, Skip Paul
See 1986 Evaluation of A2D03 - letter by Boyce to Epps.
Mailed to all members in Dec. 1988.

B. 1990 Session

1. Bituminous Mix Designs and Surface Friction.

2. Chip Seals - Designs - Construction - Evaluations.

VII. Program Presentation - "SALVIACIM PROCESS"
First introduced by the French Company, Jean Lefebve

Alyan Corp. resents the Jean Lefebve Company in U.S.
Ibrahim Murr of Alyan to make the presentation.

VIII. Adjournment and Goodbye.

ANNEXE B

DOCUMENTATION RECUEILLIE

Sessions

1 Monday 9:00 a.m., Sheraton (Annapolis)
GEOSYNTHETICS IN PAVEMENT REHABILITATION

Richard D. Barksdale, Georgia Institute of Technology, presiding

Sponsored by Committee on Geotextiles

The Durability of a Polypropylene Geotextile in an Unpaved Road Structure *880487* I. D. Peggs, GeoSyntec, Inc.; L. G. Tisinger, GeoSyntec, Inc.; R. Bonaparte, GeoServices Inc

A Field Evaluation of Engineering Fabrics for Maintenance of PCC Pavements in Ohio, Keith T. Hinshaw, Ohio Department of Transportation

* **Field Performance of Fabrics and Fibers to Retard Reflective Cracking** *880636* Dean A. Maurer, Pennsylvania Department of Transportation; G. J. Malasheskie, Pennsylvania Department of Transportation

* **Overlay Construction and Performance Using Fabrics** *880424* Joe W. Button, Texas A&M University System

Panel: Research Direction for Fabric in Pavement
I. D. Peggs, R. Bonaparte, Keith T. Hinshaw, Dean A. Maurer, Gerald J. Malasheskie, Joe W. Button

108 Tuesday, 2:00 p.m., Sheraton (Holmes)
EFFECTS OF TIRE PRESSURE ON PAVEMENT STRUCTURES

Newton Jackson, Washington State Department of Transportation, presiding

Sponsored by Committee on Flexible Pavement Design

* **Effect of Tire Pressure on Flexible Pavement Response and Performance** *880145* Ramon Bonaquist, Federal Highway Administration; Roger Surdahl, Federal Highway Administration; Walla Mogawer, University of Rhode Island

* **Effect of Tire Pressure and Tire Types on the Response of Flexible Pavement** *880230* Peter Sebaaly, Pennsylvania Transportation Institute; Nader Tabatabaee, Pennsylvania Transportation Institute

* **The Effect of Tires and Tire Pressure on Pavements** *880159* Matti Huhtala, Jari Pihlajamaki, Markku Pienimaki, Road and Traffic Laboratory, Finland

Tire Types, Pressures, and Models: An Overview, Freddy L. Roberts, Auburn University

122 Tuesday, 8:00 p.m., Sheraton (Baltimore)
FLEXIBLE PAVEMENT DESIGN AND EVALUATION FACTORS

George R. Cochran, Minnesota Department of Transportation, presiding

Sponsored by Committee on Flexible Pavement Design

Evaluating Structural Damage of Flexible Pavements Using Cracking and FWD Data *880231* Peter Sebaaly, Pennsylvania Transportation Institute; Nader Tabatabaee, Pennsylvania Transportation Institute; Ramon Bonaquist, Federal Highway Administration; David A. Anderson, Pennsylvania Transportation Institute

Analysis of Full-Depth Asphalt Concrete Pavements Using Shakedown Theory *880469* Lutfi Raad, University of Alaska; Dieter Weichert, Ruhr Universität Bochum, West Germany; Ali Haidar, American University of Beirut, Lebanon

Effects of Transverse Distribution of Heavy Vehicles on the Thickness Design of Full-Depth Asphalt Pavements *880004* R. Butter, A. C. van Eck, W. M. H. Cortenraad, H. van Rij, Ministry of Transport and Public Works, Netherlands

A Fatigue Model to Assess Pavement Damage *880578* Shekar Govind, University of Texas, Austin; C. Michael Walton, University of Texas, Austin

* **Fatigue Life and Rutting of Compacted Asphalt Concrete Mixes** *880497* Gilbert Y. Baladi, Michigan State University

140 Wednesday, 9:00 a.m., Sheraton (Baltimore)
CHARACTERIZATION OF UNBOUND GRANULAR PAVEMENT LAYERS

Thomas D. White, Purdue University, presiding

Sponsored by Committee on Strength and Deformation Characteristics of Pavement Sections and Committee on Low Volume Roads

Rapid Shear Strength Evaluation of In Situ Granular Materials *880387* Michael E. Ayers, University of Illinois, Urbana-Champaign; Marshall R. Thompson, University of Illinois, Urbana-Champaign; Donald R. Uzarski, U.S. Army Engineer Construction Engineering Research Laboratory

* **The Permanent Deformation of a Granular Material under Repeated Wheel Loading** *880522* Nicholas H. Thom, SWK Pavement Engineering, United Kingdom; Andrew R Dawson, University of Nottingham, United Kingdom

Improved Characterization Model for Granular Bases *880300* Robert P. Elliott, University of Arkansas

* **Influence of Aggregate Shape on Base Behavior** *880573* Richard D. Barksdale, Georgia Institute of Technology; Samir Itani, Georgia Institute of Technology

Shakedown and Fatigue of Pavements with Granular Bases *880514* Lutfi Raad, University of Alaska; Dieter Weichert, Ruhr Universität Bochum, West Germany; Ali Haidar, American University of Beirut, Lebanon

A Simplified Mechanistic Rut Depth Prediction Procedure for Low-Volume Roads *880384* Kashyapa A. S. Yapa, Koon Meng Chua, Robert L. Lytton, Texas A&M University System

207 Thursday, 9:00 a.m., Sheraton (South Cotillion)
WEIGH-IN-MOTION: EQUIPMENT AND ACTIVITIES

Perry M. Kent, Federal Highway Administration, presiding

Sponsored by Committee on Vehicle Counting, Classification and Weigh-in-Motion Systems

A Two-Point Vehicle Classification System *880220* B. C. McCullough, Jr., Frederic R. Harris, Inc; S. A. Ardekani, Virginia Polytechnic Institute and State University; L. R. Huang, University of Texas, Austin

* **Accuracy of Weigh-in-Motion Scales and Piezoelectric Cables** *880499* A. T. Papagiannakis, Memorial University, St. John's, Canada; William A. Phang, Pavement Management Systems; J. H. F. Woodrooffe, National Research Council, Ontario, Canada; A. T. Bergan, University of Saskatchewan, Canada; R. C. G. Haas, University of Waterloo, Canada

Traffic Measurement Standards, Lawrence E. Hart, Rainhart Company

A Summary of the Third National Conference on Weigh-in-Motion, Perry M. Kent

Piezo Sensors for Weight Enforcement Screening, Neil Ayland and Neil Emmott, Castle Rock Consultants

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FHWA-TS-87-230		

4. Title and Subtitle	
PAVEMENT RECYCLING GUIDELINES FOR LOCAL GOVERNMENTS - REFERENCE MANUAL	5. Report Date: September, 1987
	6. Performing Organization Code
7. Author(s)	8. Performing Organization Report No.
9. Performing Organization Name and Address ARE Inc - Engineering Consultants 6811 Kenilworth Avenue, #216 Riverdale, Maryland 20737	10. Work Unit No. (TRAIS) 11. Contract or Grant No.: DTFH61-85-C-00118
12. Sponsoring Agency Name and Address U.S. Department of Transportation Federal Highway Administration Washington, D.C. 20590	13. Type of Report and Period Covered: FINAL 14. Sponsoring Agency Code: HHO-12

15. Supplementary Notes

16. Abstract

Recycling processes can be categorized according to material type - asphalt surface recycling, cold-mix asphalt recycling, hot-mix asphalt recycling, and portland cement concrete recycling; or according to procedural type - surface recycling, in-place recycling and central plant recycling. If the project can be restored by making corrections to the surface, with a minimum of new materials, surface recycling will prove satisfactory. If substantial corrections are required, in-place or central plant mixed procedures should be used. Methods of mix design and structural design for pavements containing recycled materials are generally similar to those used for designing mixes containing all virgin materials. The major difference is that variability in the properties of the recycled materials needs to be taken into consideration. This necessitates more frequent sampling and testing than with conventional mixtures and greater engineering judgment on the part of the designer. Cost is the traditional criterion for selection between various rehabilitation alternatives. The alternative with the least cost, including initial and maintenance, is usually selected by the designer. In the case of recycling, the relative cost savings will depend on the costs and availability of other types of treatment, as well as those of the recycling option selected.

17. Key Words	18. Distribution Statement
Pavement Recycling, Asphalt Pavements, Concrete Pavements, Recycled Mixtures, Pavement Design, Overlay Design	No restrictions. This document is available to the public through the National Technical Information Service, Springfield, VA 22161

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
UNCLASSIFIED	UNCLASSIFIED	470	

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Technical Report Documentation Page

1. Report No. FHWA-TS-87-213	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle: Improved Methods and Equipment to Conduct Pavement Distress Surveys		5. Report Date: April 1987
		6. Performing Organization Code
7. Author(s): W.R. Hudson, G.E. Elkins, W. Uddin, and K.T. Reilley		8. Performing Organization Report No.: FH 67/2
9. Performing Organization Name and Address: ARE Inc, 2600 Dellana Lane, Austin, Texas 78746		10. Work Unit No. (TRAIS): 3C9C0063
		11. Contract or Grant No.: DTFH61-85-C-00115
12. Sponsoring Agency Name and Address: Federal Highway Administration (FHWA), Office of Implementation, 6300 Georgetown Pike, McLean, Virginia 22101		13. Type of Report and Period Covered: Final Report, September 1985 - April 1987
		14. Sponsoring Agency Code

15. Supplementary Notes

FHWA Contracting Officers Technical Representative: Mr. Douglas Brown

Appreciation is extended to the Texas State Department of Highways and Public Transportation for their cooperation.

16. Abstract

This report documents the second phase of an FHWA study, entitled "Pavement Condition Monitoring Methods and Equipment". In this phase selected distress survey methods and devices, representing a range in automation, were tested from July to September 1986. The following methods and devices were included in the testing: manual mapping, detailed visual surveys using manual recording and automatic data logging, PASCO ROADRECON survey vehicle, the GERPHO survey vehicle, the ARAN survey vehicle, and the Laser RST survey vehicle. The field tests were conducted on flexible, rigid, and composite pavements exhibiting a range of pavement distresses.

The survey devices were evaluated using performance, capability, efficiency, and cost-effectiveness criteria. The study concluded that, at present, the GERPHO and PASCO ROADRECON are best suited for pavement performance research studies due to factors such as the permanent film record, cost-effectiveness, and data quality. The GERPHO and PASCO ROADRECON are also judged to be suitable for network and project level surveys. The ARAN and Laser RST were recommended for consideration for use in network level surveys for pavement management. It is also recommended that data loggers be used to record field data for traditional manual survey techniques.

17. Key Words: Distress Survey, Condition Survey, Field Tests, Test Equipment		18. Distribution Statement: This document is available to the public through the National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, Virginia 22161	
19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages: 272	22. Price

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Technical Report Documentation Page

1. Report No. FHWA-TS-87-229	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle EVALUATION OF EQUIPMENT FOR MEASURING VOIDS UNDER PAVEMENTS		5. Report Date September 1987
		6. Performing Organization Code
		8. Performing Organization Report No. FH 67/3
7. Author(s) W. Uddin, W.R. Hudson, G.E. Elkins, and K.T. Reilley		
9. Performing Organization Name and Address ARE Inc 2600 Dellana Lane Austin, Texas 78746		10. Work Unit No. (TRAIS) NCP 3C9C 0063
		11. Contract or Grant No. DTFH61-85-C-00115
12. Sponsoring Agency Name and Address Federal Highway Administration (FHWA) Office of Implementation 6300 Georgetown Pike McLean, Virginia 22101		13. Type of Report and Period Covered Final Report August 1985-September 1987
		14. Sponsoring Agency Code

15. Supplementary Notes
FHWA Contract Manager (COTR): Doug Brown (HRT-10)
The cooperation of the Departments of Transportation of the States of Florida, Arkansas, North Carolina, Tennessee, and Oklahoma is greatly appreciated.

16. Abstract

This report documents the research performed on evaluation of equipment for measuring voids under portland cement concrete pavements. The following equipment was evaluated based on field tests conducted by several State DOT's: proof roller, the Benkelman Beam, Dynaflect, falling weight deflectometer (FWD), ground-penetrating radar (GPR) equipment developed by Gulf Applied Radar and Donohue & Associates Inc., and transient dynamic response (TDR) equipment. The devices were evaluated through information obtained from a literature search, synthesis of field test data provided by the States and additional telephone contacts conducted for this study. The field tests were performed on PCC pavements in these States during undersealing projects. Records of grout quantity were the prime source to verify voids. Cores and, in some cases, lifting of the entire PCC slabs provided further evidence of the presence of voids. GPR and TDR data were interpreted by their participants. Deflection data were interpreted by the States or analyzed in this study using standard procedures.

The report concludes that, based on the interpretation of field test data and field verifications, none of the methods or equipment can yet be classified as an excellent tool to measure voids. Deflection methods are the least satisfactory because pavement deflections are influenced by daily temperature cycles and load transfer deficiencies across transverse joints. All methods require extensive manual data analysis and data interpretation. The TDR method is very labor intensive and needs further study in relation to the influence of slab curling due to temperature cycles and the effect of load transfer inadequacy. Ground penetrating radar methods hold good promise if the data interpretation techniques are enhanced and their subjective and time-consuming reporting aspects are improved.

17. Key Words Pavements, PCC slabs, non-destructive tests, radar, dynamic, deflection, test equipment, field tests, comparison		18. Distribution Statement No restrictions. This document is available to the public through the National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, Virginia 22161.	
19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages 186	22. Price

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Technical Report Documentation Page

1. Report No. FHWA-TS-87-208	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle EVALUATION OF PAVEMENT DEFLECTION MEASURING EQUIPMENT		5. Report Date March, 1987
		6. Performing Organization Code
7. Author(s) W. R. Hudson, G. E. Elkins, W. Uddin and K. T. Reilley		8. Performing Organization Report No. FH 67/1
9. Performing Organization Name and Address ARE Inc 2600 Dellana Lane Austin, TX 78746		10. Work Unit No. (TRAIS) 3C9C0063
		11. Contract or Grant No. DTFH61-85-C-00115
12. Sponsoring Agency Name and Address Federal Highway Administration (FHWA) Office of Implementation 6300 Georgetown Pike McLean, Virginia 22101		13. Type of Report and Period Covered Final Report August 1985 - March 1987
		14. Sponsoring Agency Code

15. Supplementary Notes

FHWA Contract Manager (COTR): Doug Brown (HRT-10)

The cooperation of Texas State Department of Highways and Public Transportation, Texas Transportation Institute, and Balcones Research Center is greatly appreciated.

16. Abstract

This report documents the research performed on evaluation of pavement deflection equipment under Contract DTFH61-85-C-00115 for the Federal Highway Administration. The following devices were included in side-by-side field tests conducted in the Austin, Texas area during the week of August 11, 1986: the Benkelman Beam, C.E.B.T.P. Curviameter, Dynaflect, Dynatest Falling Weight Deflectometer (FWD), Kuab FWD, Phonix FWD and the Road Rater. The report includes descriptions and comparisons of the devices through information obtained from a literature search, field tests and user survey conducted for this study.

The side-by-side test program was performed over a broad range of pavement structures, including thick and thin flexible and rigid pavements, and composite pavements. The measured deflections were compared statistically. Mechanistic interpretations of the measured deflection basins were made and compared.

The report concludes that, based on the interpretation of field data, all devices gave comparable results on the tested pavements, except the Curviameter which gives invalid results on rigid and composite pavements. In addition, the Benkelman Beam and Curviameter exhibited much larger variability in comparison with the other devices.

17. Key Words Pavements, non-destructive tests, deflection, test equipment, field tests, side-by-side comparison	18. Distribution Statement This document is available to the public through the National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, Virginia 22161

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		170	

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Technical Report Documentation Page

1. Report No. FHWA/RD-85/101	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle IN-SITU DETERMINATION OF MOISTURE LEVELS IN STRUCTURAL CONCRETE BY MODIFIED NMR		5. Report Date July 1987
		6. Performing Organization Code
7. Author(s) G.A. Matzkanin and A. De Los Santos		8. Performing Organization Report No. 15-7558
9. Performing Organization Name and Address Southwest Research Institute 6220 Culebra Road San Antonio, TX 78284		10. Work Unit No. (TRAIS) 35Q2064
		11. Contract or Grant No. DTFH61-83-C-00015
12. Sponsoring Agency Name and Address Office of Engineering Highway Operations, R&D Federal Highway Administration U.S. Department of Transportation		13. Type of Report and Period Covered Final Report 4/19/83 to 7/31/85
		14. Sponsoring Agency Code S01380

15. Supplementary Notes FHWA Contract Manager: Y.P. Virmani, HNR-10
Field tests in Wichita Falls, TX performed with permission and cooperation of District 3 Construction Engineer, Mr. Frank Craig. Traffic control provided by District 3 Maintenance personnel.

16. Abstract
The prototype bridge deck Nuclear Magnetic Resonance (NMR) Moisture Measurement System was modified to improve its usefulness and field tested in Wichita Falls, Texas, and at the FHWA Turner-Fairbank Research Center in McLean, Virginia. Modifications included addition of an external control unit to provide for selection of desired measurement depths and automatic adjustment of the RF pulses and magnetic field for the selected measurement depth and rebar depth. Field tests were conducted on 8 bridge decks having a variety of overlays in the Wichita Falls area and on 12 concrete test slabs having a variety of rehabilitation systems at the FHWA center. The NMR system performed well under adverse field conditions and the NMR results were generally repeatable down to depths of 2 in (51 mm). At deeper depths, repeatability was sometimes affected by interferences from rebars. The NMR moisture readings generally increased with increasing depth consistent with expectations for thick slabs exposed to surface drying, and the NMR results were unaffected by overlays up to 2 in (51 mm) thick. Good qualitative agreement was obtained between the NMR moisture results and those obtained from dry core samples at selected locations, except that the NMR results tended to be more consistent. For the FHWA test slabs, the NMR moisture values for the concrete were found to increase with increasing water/cement ratio and decrease with increasing concrete density.

17. Key Words Moisture Measurement, Nuclear Magnetic Resonance, NMR, Structural Concrete, Reinforced Concrete, Nondestructive Evaluation	18. Distribution Statement No restrictions. This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	51	

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FROST ACTION PREDICTIVE TECHNIQUES FOR ROADS AND AIRFIELDS

Research, Development
and Technology

Turner-Fairbank Highway
Research Center
6300 Georgetown Pike
McLean, Virginia 22101-2296

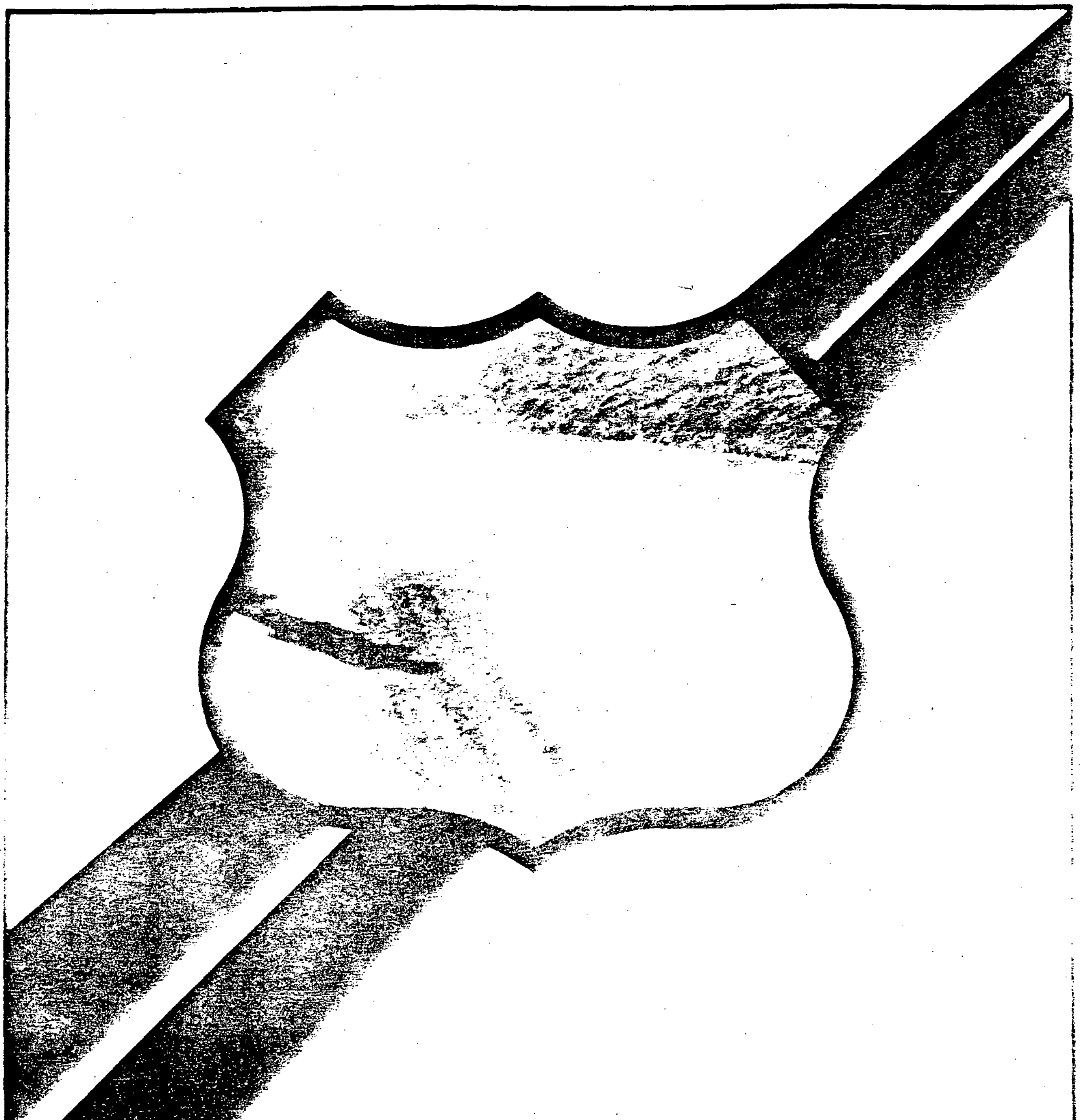
Report No.
FHWA/RD-87/057

VOL. I: A COMPREHENSIVE SURVEY OF RESEARCH FINDINGS

U.S. Department
of Transportation

**Federal Highway
Administration**

Final Report
June 1987



U.S. Department
of Transportation

**Federal Highway
Administration**

**FHWA Contact:
Charles Churilla, HNR-20
(703) 285-2074**

Research, Development,
and Technology

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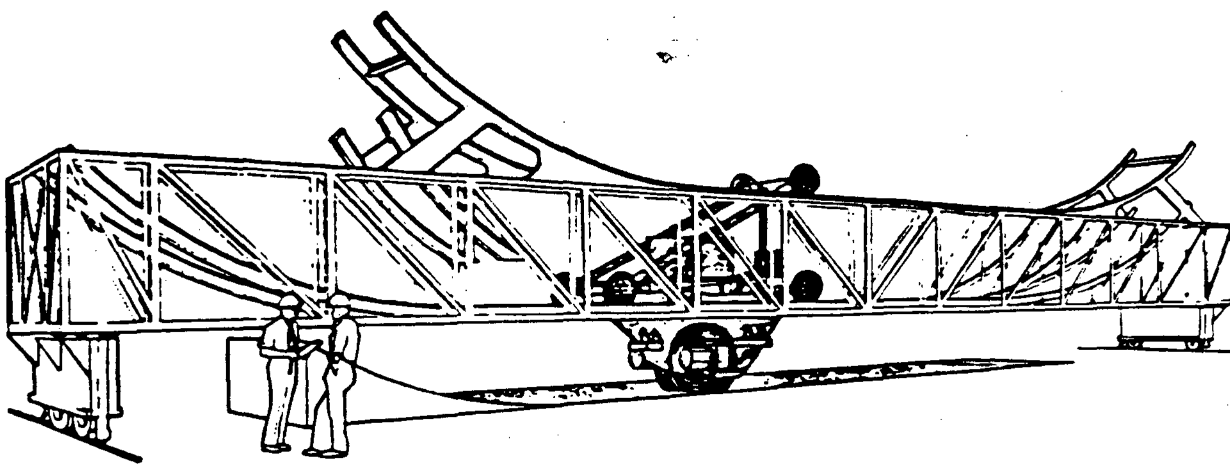
McLean, Virginia 22101-2296

HIGH PRIORITY NATIONAL PROGRAM AREA (HPNPA)

ACCELERATED EVALUATION OF PAVEMENT PERFORMANCE

PAVEMENTS DIVISION, HNR-20
AUGUST 1988

Pavements



Accelerated Loading Facility Machine

BACKGROUND

The American Association of State Highway Officials (AASHO) Road Test conducted in 1958 was the last significant national effort to advance the design of pavements. Through the use of full-scale accelerated trafficking of test sections, AASHO was able to produce a design procedure that continues to serve the highway industry. Today, 30 years later, highway materials, construction procedures, and traffic loadings are significantly different. Our highway system is experiencing an increasing frequency of premature pavement failures.

To provide the structural and materials design and construction procedures for today's and tomorrow's pavements, FHWA has begun a national program for the Accelerated Evaluation of Pavement Performance. This activity is one component of an integrated national pavement research effort that includes the Strategic Highway Research Program (SHRP) and States' highway research. This program is closely integrated with SHRP's "Long-Term Pavement Performance" and "Asphalt" research areas, and State's pooled-fund research.

GOAL

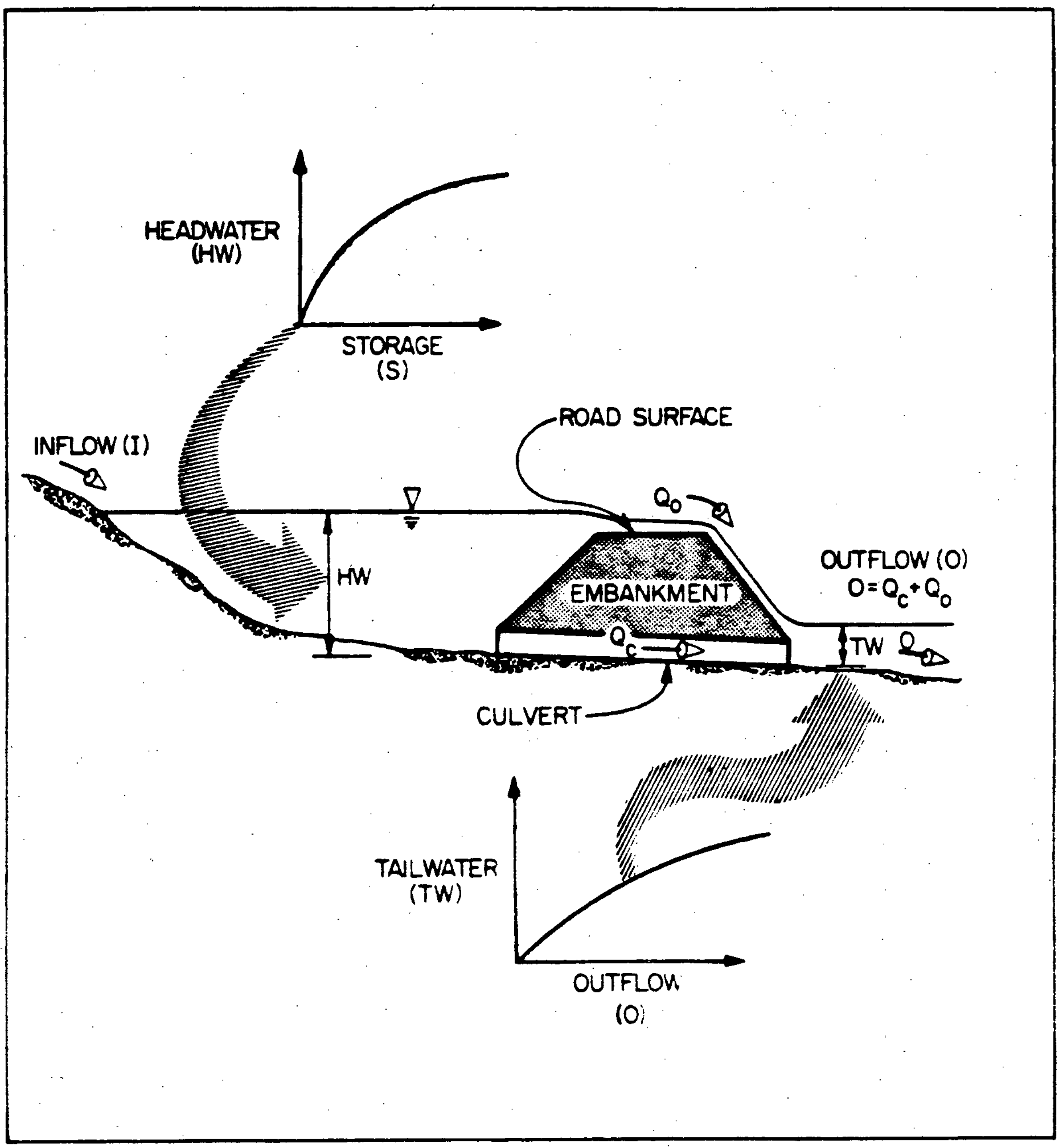
To improve the cost-effectiveness of highway pavements through accelerated evaluation of pavement designs, materials, and construction practices.

(FHWA-RD-88-203)

HIGHWAY DRAINAGE
Core Curriculum

U.S. Department
of Transportation

Federal Highway
Administration



A PROGRAM OF STUDY IN PAVEMENT MANAGEMENT

Volume I

Participant Notebook
Lessons 1–31

THE CENTER FOR TRANSPORTATION RESEARCH
BUREAU OF ENGINEERING RESEARCH
THE UNIVERSITY OF TEXAS AT AUSTIN

A PROGRAM OF STUDY IN PAVEMENT MANAGEMENT

Volume II

Participant Notebook
Lessons 32–60

Prepared by

THE CENTER FOR TRANSPORTATION RESEARCH
BUREAU OF ENGINEERING RESEARCH
THE UNIVERSITY OF TEXAS AT AUSTIN

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

SUMMARY OF PROGRESS THROUGH 1988

SPECIAL EDITION

This Summary of Progress is a compilation of information on all projects initiated under the NCHRP from its inception in 1962 through 1988. Annually, for 27 years, the National Cooperative Highway Research Program has issued a Summary of Progress comprised of up-to-date status reports on all on-going projects and brief statements on those that have been completed. With rising publication costs, and in the interest of keeping this book within manageable size, future summaries will not contain the completed projects that are found in this volume. Therefore, it is suggested that this edition be preserved as the last complete source of information on all NCHRP projects. Subsequent editions will update the Summary of Progress series, including only projects active after January 1, 1989.

TRANSPORTATION RESEARCH BOARD
NATIONAL RESEARCH COUNCIL

Special Report 87-15

August 1987
(Revised September 1988)

US Army Corps
of Engineers
Cold Regions Research &
Engineering Laboratory

Rating Unsurfaced Roads
A field manual for measuring maintenance problems

R.A. Eaton, S. Gerard and D.W. Cate

ASPHALT TECHNOLOGY NEWS

A Publication of The National Center for Asphalt Technology, Auburn University

JANUARY 1989

SHARING ASPHALT NEWS AND RESEARCH

ASPHALT TECHNOLOGY NEWS, a newsletter for everyone involved with the asphalt industry, begins publication with this issue. This newsletter is produced by the National Center for Asphalt Technology and will be published and mailed to you twice yearly in January and July.

The NATIONAL CENTER FOR ASPHALT TECHNOLOGY (NCAT) was created in September 1986 by an agreement between the National Asphalt Pavement Association (NAPA) Education Foundation and Auburn University. Auburn University brings to the agreement its facilities and faculty and a commitment from the University administration to make NCAT a success. Since 1986 the University has purchased approximately $250,000 worth of research equipment for testing asphalt materials. Reports on current NCAT research are carried in this issue and will remain a regular feature of *Asphalt Technology News*.

Direction for NCAT is provided by the NCAT Board of Directors, which consists of 13 members, including industry representatives and university research specialists from across the United States.

The NCAT staff at Auburn is comprised of eight specialists who come from every stage of involvement with the asphalt and asphalt paving industry. The experience of this team of engineers, chemists, and field practitioners includes work in academic and industrial roles—for the private sector as well as state and U.S. agencies and the governments of foreign countries.

The NCAT Board of Directors has established three major goals that NCAT is pursuing: Education, Research, and Information Services. These three goals are detailed on the following page.

This publication, with an initial circulation of 4,000, will fulfill one of the aims of the Information Service. To keep you apprised of NCAT activities and industry developments in the U.S. and abroad, the following features will appear regularly in *Asphalt Technology News*:

- **NCAT Research Update**
- **Putting Research Into Practice** (research digests)
- **Asphalt Research in Progress** by various agencies including State DOTs
- **New Reports and Publications** available at NCAT
- **SHRP Asphalt Research Update**
- **Developing Issues** (state and national level) in asphalt technology
- **Specifications Corner** (changes and problems)
- **Asphalt Forum** (Questions and comments from DOTs and Industry)

Continued on page 13

In this Issue

U.S. Department
of Transportation
**Federal Highway
Administration**

State and Local Highway Training and Technology Resources

RT-88-001

July 1988

Research, Development and
Technology
National Highway Institute

Long-lasting bridge decks with latex modified concrete

DOW

A Handbook On Portland Cement Concrete & Mortar Containing Styrene/Butadiene Latex

LATEX MODIFIED CONCRETE

ANNEXE C

LISTE DES CONFÉRENCIERS

*Participants**

*Numbers refer to sessions, page numbers indicate unnumbered events.

ANNEXE D

AGENDA DE LA RÉUNION DU SHRP

Strategic Highway Research Program
State Coordinators Meeting

Sunday, January 22, 1989

8:30 A.M. Continental Breakfast

9:00 Welcome
- o Goals and Objectives of this meeting — John Tabb
- o SHRP - PAST-PRESENT-FUTURE — Damian Kulash
  - o Products
  - o Amount of state involvement
  - o Types of state involvement
  - o Status of contracts
  - o Ways to keep them useful

Discussion

9:45 Long Term Pavement Performance — Neil Hawks
- o General Pavement Studies (GPS)
  - Progress within the General Pavement Studies
  - How confident are we with the existing number of sites
  - What benefits will come from the GPS experiments
- o Specific Pavement Studies (SPS)
  - Is SPS meeting the Goals/Objectives of SHRP
  - How each state can benefit from SPS
  - The products of the Maintenance Effectiveness Experiments (SPS-3, SPS-4)

Where will LTPP be next year at this time?

10:15 Questions, Answers and Discussion
Long Term Pavement Performance - GPS/SPS

11:00 FHWA - SHRP - AND YOU — Norm Van Ness
- o Overall Support FHWA
- o Funding of SHRP's Four Areas
  - Asphalt
  - Concrete/Structures
  - Highway Operations
  - LTPP
    - * GPS
    - * SPS

11:30 A.M.	Questions, Answers and Discussion Funding from FHWA	
12:00 Noon	Lunch	
1:00 P.M.	Your Regional Engineers - A Panel Discussion	
	o Your Regional Engineer, working with you for the success of SHRP	Richard Ingberg
	o How a working committee within your state can benefit you	Calvin Berge
	o Benefits of a statewide project for all SHRP activities	Homer Wheeler
	o Details of the Drilling, Sampling and Field Testing Program	Ivan Pecnik
1:40	Open Discussion	
2:15	Concrete/Structures	Jim Murphy
	o Products of the Concrete/Structures Program	
	o Your Participation in Concrete/Structures	
	o What we Know Now	
	o Where We Will Be One Year From Now	
2:40	Questions, Answers and Discussion Concrete/Structures	
3:00	Break	
3:15	SHRP	
	Asphalt	Don Harriott
	o Products of the Asphalt Program	
	o Where we are now	
	o Where we will be a year from now	
	o State activities in the Asphalt Program	
3:40	Questions, Answers and Discussion Asphalt	
4:55	Wrap-Up	John Tabb
5:00	Adjourn	
	Reception - Washington Ballroom - immediately following meeting	

ANNEXE E

LISTE DES PRINCIPALES PERSONNES RENCONTRÉES

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Product Manager Southern Region

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ANNEXE F

GUIDE POUR LA COLLECTE DES DONNÉES DE TRAFIC SUR LES SECTIONS SHRP

NATIONAL RESEARCH COUNCIL

STRATEGIC HIGHWAY RESEARCH PROGRAM

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DAMIAN J. KULASH
Executive Director

DATE: JANUARY 17, 1989

FROM: DAMIAN KULASH

TO: STATE AND PROVINCIAL COORDINATORS

RE: GENERAL PAVEMENT STUDIES - TRAFFIC DATA COLLECTION

An operational memorandum titled "Framework for Traffic Data Collection for the General Pavement Studies Test Sections" has been prepared by SHRP staff. The operational memorandum reflects both the recommendations provided to SHRP by the expert task groups for Weigh-In-Motion Technology and Data Collection and Analysis and the subsequent LTPP advisory committee's action on the recommendations. A copy of the memorandum is attached for your information.

The operational memorandum outlines a general framework for traffic data collection for the GPS sections. SHRP's staff and consultants are now in the process of developing specific guidelines within this framework to govern the actual collection of data. A draft of these guidelines, which will form a chapter in the SHRP Data Collection Manual, will be available by the end of March.

Throughout early 1989, The Federal Highway Administration will be conducting courses for the state highway agencies on "Application of the Traffic Monitoring Guide." SHRP staff will make presentations on the SHRP data collection requirements at these courses. This will provide face-to-face contact between SHRP staff and your traffic data collection experts without requiring your staff to attend yet another meeting specifically for SHRP's needs. Although application of the TMG does not directly concern SHRP, it is part of the environment in which your decisions for future traffic data collection will be made. Concurrent presentation of SHRP needs with the FHWA course may aid you and your staff in reaching those decisions.

The implementation window for each of the SHRP data collection elements along with the general schedule is provided below.

```
                        |--1989--|--1990--|--1991--|--1992--|--1993--
                        :        :        :        :        :
Traffic Courses         : |->    :        :        :        :
                        :        :        :        :        :
Historical inform-      :        :        :        :        :
ation to SHRP           :     |--------------------->       :
                        :        :        :        :        :
AVC installation        :|--------------------->   :        :
                        :        :        :        :        :
                        :        :        :        :        :

1 yr truck season       :        :        :        :        :
short term WIM          :|------------------------------>   :
counts                  :        :        :        :        :
                        :        :        :        :        :
New regional WIM        :        :        :        :        :
installations           :   |------------------>   :        :
                        :        :        :        :        :
GPS site WIM            :        :        :        :        :
installation            :|--------------------->   :        :
(if applicable)         :        :        :        :        :
```

In response to requests raised at the regional workshops, SHRP has prepared lists of automatic vehicle classification and weigh-in-motion suppliers and compiled information from a number of the suppliers. The lists were prepared from information collected at a weigh-in-motion conference held in Minneapolis, Minnesota and obtained from the HELP project. The attached lists are not all inclusive. Because of its bulk, the material compiled from the equipment suppliers is not attached but will be distributed at the January 22 coordinators meeting.

SHRP looks forward to your participation at the January coordinators' meeting and the traffic workshop.

DRAFT

DATE ____-____-____

*STATE ASSIGNED ID _ _ _ _

*STATE CODE _ _

*SHRP SECTION ID _ _ _ _

*SHRP REGION CODE _ _

NAME ____________________

PHONE # ____________________

SHEET 1

HISTORICAL TRAFFIC DATA

LIPP PROGRAM

ESTIMATED ANNUAL TRAFFIC

LOCATION ____________________

CROSS-SECTION ________________

CONSTRUCTION DATE ____-____-____

*ANNUAL GROWTH FACTORS USED TO ESTIMATE ADT IN NON-COUNT YEARS

YEAR	1. ESTIMATED ADT	2. DIRECTIONAL DISTRIBUTION	3. PER CENT TRUCKS	4. ADT* GROWTH FACTOR	5. SOURCE CODE
1988					
1987					
1986					
1985					
1984					
1983					
1982					
1981					
1980					
1979					
1978					
1977					
1976					
1975					
1974					

DRAFT

SHEET 1A

HISTORICAL TRAFFIC DATA
(ADDITIONAL DATA SHEET)

LTPP PROGRAM

ESTIMATED ANNUAL TRAFFIC

DATE ____-____-____

*STATE ASSIGNED ID _ _ _ _

*STATE CODE _ _

*SHRP SECTION ID _ _ _ _

*SHRP REGION CODE _ _

NAME ____________

PHONE # ____________

LOCATION ____________

CROSS-SECTION ____________

CONSTRUCTION DATE ____-____-____

*ANNUAL GROWTH FACTORS USED TO ESTIMATE ADT IN NON-COUNT YEARS

YEAR	1. ESTIMATED ADT	2. DIRECTIONAL DISTRIBUTION	3. PER CENT TRUCKS	4. ADT* GROWTH FACTOR	5. SOURCE CODE
1973	_ _ _ _ _ _	_ _	_ _	_ _ _	_ _
1972	_ _ _ _ _ _	_ _	_ _	_ _ _	_ _
1971	_ _ _ _ _ _	_ _	_ _	_ _ _	_ _
1970	_ _ _ _ _ _	_ _	_ _	_ _ _	_ _
1969	_ _ _ _ _ _	_ _	_ _	_ _ _	_ _
1968	_ _ _ _ _ _	_ _	_ _	_ _ _	_ _
1967	_ _ _ _ _ _	_ _	_ _	_ _ _	_ _
1966	_ _ _ _ _ _	_ _	_ _	_ _ _	_ _
1965	_ _ _ _ _ _	_ _	_ _	_ _ _	_ _
1964	_ _ _ _ _ _	_ _	_ _	_ _ _	_ _
1963	_ _ _ _ _ _	_ _	_ _	_ _ _	_ _
1962	_ _ _ _ _ _	_ _	_ _	_ _ _	_ _
1961	_ _ _ _ _ _	_ _	_ _	_ _ _	_ _
1960	_ _ _ _ _ _	_ _	_ _	_ _ _	_ _
1959	_ _ _ _ _ _	_ _	_ _	_ _ _	_ _

DRAFT

DATE ___-___-___

SHEET 2

HISTORICAL TRAFFIC DATA

LTPP PROGRAM

*STATE ASSIGNED ID _ _ _ _

*STATE CODE _ _

*SHRP SECTION ID _ _ _ _

*SHRP REGION CODE _ _

ACTUAL TRAFFIC COUNTS ON SHRP SECTION OR SAME VOLUME-DEFINED ROAD SEGMENT

LOCATION ________________ MILEPOST # ______

TYPE OF COUNTER ________________ NAME ________________

DATA ITEMS	MOST RECENT YEAR	PREVIOUS YEAR COUNTS YEAR ______	YEAR ______
1. DATE (MONTH-DAY-YEAR)	___-___-___	___-___-___	___-___-___
2. PERIOD (HOURS)	_ _	_ _	_ _
3. RAW COUNT	_ _ _ _ _ _	_ _ _ _ _ _	_ _ _ _ _ _
4. ADJUSTMENT A. SEASONAL FACTOR USED	_ _ _	_ _ _	_ _ _
A. SOURCE	______	______	______
B. AXLE CORRECTION FACTOR USED	_ _ _	_ _ _	_ _ _
B. SOURCE OF AXLE CORRECTION FACTOR	_ _ _	_ _ _	_ _ _
C. OTHER FACTOR (SPECIFY TYPE)	_ _ _	_ _ _	_ _ _
C. FACTOR USED	_ _ _	_ _ _	_ _ _
C. SOURCE-OTHER FACTOR	______	______	______
5. DIRECTIONAL DISTRIBUTION FACTOR IF COLLECTED DURING COUNT	_ _ _	_ _ _	_ _ _
6. DIRECTIONAL DISTRIBUTION FACTOR IF ESTIMATED	_ _ _	_ _ _	_ _ _
7. TRUCK LANE DISTRIBUTION FACTOR IF COLLECTED DURING COUNT	_ _ _	_ _ _	_ _ _
8. TRUCK LANE DISTRIBUTION FACTOR IF ESTIMATED	_ _ _	_ _ _	_ _ _
9. PERCENTAGE OF TRUCKS TO TOTAL ADT VOLUME	_ _	_ _	_ _

DRAFT

DATE ___-___-___

*STATE ASSIGNED ID _ _ _ _

*STATE CODE _ _

*SHRP SECTION ID _ _ _ _

*SHRP REGION CODE _ _

NAME ____________

SHEET 3

HISTORICAL TRAFFIC DATA

LTPP PROGRAM

VEHICLE CLASSIFICATION DATA

PERCENT OF TRUCK VOLUME BY VEHICLE CLASS

LOCATION ______________________ MILEPOST ____________

DATE OF COUNT	__-__-__	__-__-__	__-__-__	__-__-__
TOTAL ADT	______	______	______	______
% TRUCKS	______	______	______	______
1. TRUCK CLASS A	_ _	_ _	_ _	_ _
2. TRUCK CLASS B	_ _	_ _	_ _	_ _
3. TRUCK CLASS C	_ _	_ _	_ _	_ _
4. TRUCK CLASS D	_ _	_ _	_ _	_ _
5. TRUCK CLASS E	_ _	_ _	_ _	_ _
6. TRUCK CLASS F	_ _	_ _	_ _	_ _
7. TRUCK CLASS G	_ _	_ _	_ _	_ _
8. TRUCK CLASS H	_ _	_ _	_ _	_ _
9. TRUCK CLASS I	_ _	_ _	_ _	_ _
10. TRUCK CLASS J	_ _	_ _	_ _	_ _
TOTAL (SHOULD EQUAL 100%)	_ _ _	_ _ _	_ _ _	_ _ _

DRAFT

DATE ___-___-___

*STATE ASSIGNED ID _ _ _ _

*STATE CODE _ _

*SHRP SECTION ID _ _ _ _

*SHRP REGION CODE _ _

SHEET 4

HISTORICAL TRAFFIC DATA

LTPP PROGRAM

DETAILS OF CLASSIFICATION COUNTS

1. YEAR _ _ _ _

2. PERMANENT COUNTER
   __ ON SHRP COUNTER
   __ ON SAME ROUTE AS SHRP SECTION
      LOCATION ______________ MILEPOST # ______________
   __ INDIVIDUAL COUNTER ON SAME FUNCTIONAL CLASS DIFFERENT ROUTE
      ROUTE NUMBER OF COUNTER ______________
      LOCATION ON ROUTE ______________
      FUNCTIONAL CLASS ______________
   __ MEAN OF MULTIPLE COUNTERS ON SAME FUNCTIONAL CLASS
      NUMBER OF COUNTERS ______________

3. SHORT TERM COUNT ON SHRP SECTION ROUTE
      LOCATION OF COUNTER ______________
      COUNT DATE __________ MONTH __________ DAY(S)
   __ MANUAL COUNT
   __ MECHANICAL COUNT - SPECIFY EQUIPMENT: ______________

4. SHORT TERM COUNT ON OTHER ROUTES - SAME FUNCTIONAL CLASS
   NUMBER OF COUNTS USED TO COMPUTE MEAN STATISTIC __________
   NUMBER OF COUNT LOCATIONS __________

DATES:	MONTH	DAYS	MONTH	DAYS	MONTH	DAYS	MANUAL	MECHANICAL
LOCATION 1	___	___	___	___	___	___	___	___
LOCATION 2	___	___	___	___	___	___	___	___
LOCATION 3	___	___	___	___	___	___	___	___
LOCATION 4	___	___	___	___	___	___	___	___
LOCATION 5	___	___	___	___	___	___	___	___
LOCATION 6	___	___	___	___	___	___	___	___
LOCATION 7	___	___	___	___	___	___	___	___

5. COMMENTS ON OTHER DETAILS OF CLASSIFICATION COUNTS

____

____

____

6. IF YOUR AGENCY CURRENTLY USES DIFFERENT VEHICLE CLASSES THAN THOSE SHOWN ON SHEET, PLEASE LIST CURRENT VEHICLE COUNT CLASSES

____

____

____

DRAFT

SHEET 5

HISTORICAL TRAFFIC DATA

LTPP PROGRAM

TRUCK AXLE LOAD MEASUREMENTS

WEIGHT STATION DESCRIPTION

DATE __-__-__

*STATE ASSIGNED ID _ _ _ _

*STATE CODE _ _

*SHRP SECTION ID _ _ _ _

*SHRP REGION CODE _ _

NAME ____________

PHONE # ____________

1. STATION IDENTIFICATION NUMBER _ _ _
2. FUNCTIONAL CLASSIFICATION _ _
3. POSTED ROUTE NUMBER CATEGORY _
4. POSTED ROUTE NUMBER _ _ _ _
5. DIRECTION OF TRAVEL _
6. TYPE OF SITE _
7. TYPE OF WEIGHING EQUIPMENT _
8. SCALE MANUFACTURER ____________
9. MODEL NUMBER OF SCALE ____________
10. METHOD OF VEHICLE CLASSIFICATION COUNTING _
11. COORDINATION WITH ENFORCEMENT ACTIVITIES _
12. LOCATION OF STATION (DISTANCE AND DIRECTION FROM NEAREST MAJOR INTERSECTION) ____________
13. PAVEMENT TYPE (FLEXIBLE, RIGID) _
14. DATE WIM SITE INSTALLED __-__-__
15. STATUS OF CURRENT OPERATION _

DRAFT

DATE ___-___-___

*STATE ASSIGNED ID _ _ _ _

*STATE CODE _ _

*SHRP SECTION ID _ _ _ _

*SHRP REGION CODE _ _

NAME ________________

PHONE # ________________

SHEET 6

HISTORICAL TRAFFIC DATA

LTPP PROGRAM

TRUCK AXLE LOAD MEASUREMENTS

AXLE LOAD DATA

1. STATION IDENTIFICATION NUMBER _ _ _
2. COUNT DURATION:
   FROM (MONTH, DAY, YEAR, TIME) __-__-__-_ _ _ _
   TO (MONTH, DAY, YEAR, TIME) __-__-__-_ _ _ _
3. COUNT LANE _
4. VEHICLE CLASS _ _
5. TOTAL NUMBER OF VEHICLES COUNTED _ _ _ _ _ _ _

6. SINGLE AXLES

LOAD RANGE	NUMBER OF AXLES COUNTED
< 3000	_ _ _ _ _ _
3000 - 6999	_ _ _ _ _ _
7000 - 7999	_ _ _ _ _ _
8000 - 11999	_ _ _ _ _ _
12000 - 15999	_ _ _ _ _ _
16000 - 18000	_ _ _ _ _ _
18001 - 18500	_ _ _ _ _ _
18501 - 20000	_ _ _ _ _ _
20001 - 21999	_ _ _ _ _ _
22000 - 23999	_ _ _ _ _ _
24000 - 25999	_ _ _ _ _ _
26000 - 29999	_ _ _ _ _ _
> 30000	_ _ _ _ _ _

7. TANDEM AXLES

LOAD RANGE	NUMBER OF AXLES COUNTED
< 6000	_ _ _ _ _ _
6000 - 11999	_ _ _ _ _ _
12000 - 17999	_ _ _ _ _ _
18000 - 23999	_ _ _ _ _ _
24000 - 29999	_ _ _ _ _ _
30000 - 32000	_ _ _ _ _ _
32001 - 32500	_ _ _ _ _ _
32501 - 33999	_ _ _ _ _ _
34000 - 35999	_ _ _ _ _ _
36000 - 37999	_ _ _ _ _ _
38000 - 39999	_ _ _ _ _ _
40000 - 41999	_ _ _ _ _ _
42000 - 43999	_ _ _ _ _ _
44000 - 45999	_ _ _ _ _ _
46000 - 49999	_ _ _ _ _ _
50000 >	_ _ _ _ _ _

DRAFT

DATE ___-___-___

*STATE ASSIGNED ID _ _ _ _

*STATE CODE _ _

*SHRP SECTION ID _ _ _ _

*SHRP REGION CODE _ _

NAME ______________

PHONE # ______________

SHEET 7

HISTORICAL TRAFFIC DATA

LTPP PROGRAM

TRUCK AXLE LOAD MEASUREMENTS

AXLE LOAD DATA

UNIQUE AXLE GROUPS

1. STATION IDENTIFICATION NUMBER _ _ _

2. COUNT DURATION:
   FROM (MONTH,DAY,YEAR,TIME) ___-___-___-_ _ _ _
   TO (MONTH,DAY,YEAR,TIME) ___-___-___-_ _ _ _

3. COUNT LANE _

4. VEHICLE CLASS _ _

5. AXLE LOAD DATA
   AXLE A LOAD (lb) _ _ _ _ _ _

   AXLE B LOAD (lb) _ _ _ _ _ _

   AXLE C LOAD (lb) _ _ _ _ _ _

   AXLE D LOAD (lb) _ _ _ _ _ _

   AXLE E LOAD (lb) _ _ _ _ _ _

6. AXLE SPACING
   SPACING BETWEEN AXLES A - B (feet and tenths) _ _._

   SPACING BETWEEN AXLES B - C (feet and tenths) _ _._

   SPACING BETWEEN AXLES C - D (feet and tenths) _ _._

   SPACING BETWEEN AXLES D - E (feet and tenths) _ _._

7. VEHICLE DESCRIPTION ______________

____

8. DATE ___-___-___

9. TIME _ _:_ _

WEIGH-IN-MOTION EQUIPMENT SUPPLIERS

The following list was prepared from information collected at a Weigh-in-Motion conference in Minnesapolis, Minnesota and from the Heavy Vehicle Electronic License Plate Program. The list is provided only as general information and is not all inclusive.

Bridge Weighing Systems, Inc.

Contact: Richard Snyder
University Circle Research Center 1
1100 Cedar
Cleveland, OH 44106
(216) 229-8400

Type: Portable Bridge WIM systems.

CMI - Dearborn, Inc.

Contact: Jeff Davies
820 Lafayette Road
Building #1, Suite 203
Hampton, NH 03842

Type: Complete weight stations including dynamic axle sensors

Culway

Contact: Snowy Mountains Engineering Coporation
P.O. Box 356
Cooma NSW 2630 AUSTRALIA
Telphone: International 61-64-520222
Telex: SMEC AA61153
Fax: International 61-64-520400

Type: Permanent bridge Wim system

Data Instrument AS

Contact: Datainstrument AS
Nye Sandviksvel 56A
P.O. Box 1561
N - 5035 Bergen Norway
Telephone: 47 5 31 14 15
Telex: 40941
Fax: 47 5 32 33 96

Type: High-speed, permanent, Piezo electric cable

Dynec Corporation

Contact: P.O. Box 15123
Austin, TX 78761

EMX Corporation

Contact: George Pagonis
1120 Connecticut Avenue, NW
Washington, DC 20036
(202) 452-8811

GK Instruments, Ltd.

Contact: Geoff Kent
Simpson Road
Fenny Stratford
Milton Keynes, MK1 I1N
England
011-44 908 75742

Type: High-speed, permanent, piezo electric WIM system

Golden River Corporation

Contact: Waltr O'Connell
7672 Standish Place
Rockville, MD 20855
(301) 340-6800

Type: Portable, high-speed, bending plate

Intercomp

Contact: 14465 23rd Avenue North
Minneapolis, Minnesota 55447-3438
Telephone: (612) 476-2531
Toll-free out of State Watts: 1-800-328-3336
Fax: (612) 476-2613

Type: Portable low speed bending plate

International Road Dynamics, Inc.

Contact: Terry Bergan
#A5-116 103rd Street
Saskatoon, Saskatchewan, CANADA S7N 1Y7
Telephone: (306) 955-3626
Fax: (306) 373-5781

Type: High speed, permanent, Piezo electric WIM system Portable bending plate wheel load systems. Portable and permanent bending plate axle load scales. Low speed single axle WIM system

PAT Equipment Corporation

Contact: Joe Madek
1161 Worcester Road, Suite 300
Framingham, MA 01701
(617) 872-8211

Siegfried Gasser
7575 Ettlingen
Hertzstrasse 32-34
Karlsruhe
West Germany

Type: Low speed, portable, bending plate. Portable static bending plate. Portable stationary traffic measuring WIM system

Streeter - Richardson

Contact: Susan Smith
155 Wicks Street
Grayslake, IL 60030
(312) 223-4801

Type: Portable and permanent bending plate WIM system

Toledo Scale

Contact: Systems Division
60 Collegeview Road
Westerville, OH 43081
Telehone: (614) 898-5110
Toll-free: 1-800-523-5123

Type: Low and medium speed WIM systems

Trevor Deakin Consultants, LTD

Contact: Ascot Court, White Horse Technology Park
Trowbridge, Wilts BA14 0XA
Telephone: Trowbridge (0225) 760099
Tele: 449441 Gage G
Fax: (0225) 762751
Cables: Technique, Rode, Bath

Type: High speed, permanent, Piezo electric system

Truvelo

Contact: AVIAR, Inc.
P.O. Box 162184
Austin, TX 78716
Telephone: (512) 327-9439
Fax: (512) 327-0822

Type: Variable speed, permanent and portable Capacitance pad WIM systems. Piezo axle detactors, axle weight sensors

Weighwrite Ltd.

Contact: Len Gorman
49 West Street
Farnham, Surrey
England
011-44 252-711011

AUTOMATIC VEHICLE CLASSIFICATION EQUIPMENT SUPPLIERS

The following list was prepared from information collected at a Weigh-in-Motion conference in Minneapolis, Minnesota and from the Heavy Vehicle Electronic License Plate Program. The list is provided only as general information and is not all inclusive.

Bridge Weighing Systems, Inc.

Contact: University Circle Research Center #1
11000 Cedar Avenue
Cleveland, OH 44106
Telephone: (216) 229-8400
Telex: 985662 (PILE DYN)
Fax: (216) 831-0916

CMI - Dearborn, Inc.

Contact: Jeff Davies
820 Lafayette Road
Building #1, Suite 203
Hampton, NH 03842
(603) 926-1200

Diamond Counters

Contact Guy Gibson
P.O. Box 691
Oakridge, OR 97463
(503) 782-3903

GEC Traffic Automation Ltd.

Contact: J. K. Beadsmore, Director
Elstree Way
Borehamwood
Hertfordshire, WD6 1RX
England
011-44 195 66786
Fax: 011-44 195 35262

GK Instruments, Ltd.

Contact: Geoff Kent
Simpson Road
Fenny Stratford
Milton Keynes, MK1 1LN
England
011-44 908 75742

Golden River Corporation

Contact: Walter O'Donnell
7672 Standish Place
Rockville, MD 20855
(301) 340-6800

International Road Dynamics, Inc.

Contact: Terry Bergan
#A5-116 103rd Street
Saskatoon, Saskatchewan, CANADA S7N 1Y7
Telephone: (306) 955-3626
Fax: (306) 373-5781

Pile Dynamics

Contact: Garland Likins
4535 Emery Industrial Parkway
Cleveland, OH 44128
Telephone: (216) 831-6131
Telex: 985662 (PILE DYN)
Facsimile: (216) 831-0916

Sarasota Automation

Contact: Mike Weeks
1500 N. Washington Boulevard
Sarasota, FL 33577
Telephone: (813) 366-8770
Fax: (813) 365-0837

Streeter - Richardson

Contact: Susan Smith
155 Wicks Street
Grayslake, IL 60030
(312) 223-4801

Timelapse

Contact: Gerald Schiff
St. Petersburg , Florida
(813) 579-8848

Operational Memorandum No.
SHRP-LTPP-OM-003

National Research Council

STRATEGIC HIGHWAY RESEARCH PROGRAM

FRAMEWORK FOR TRAFFIC DATA COLLECTION FOR THE GENERAL PAVEMENT STUDIES' TEST SECTIONS

STRATEGIC HIGHWAY RESEARCH PROGRAM
818 Connecticut Avenue NW
Washington, DC 20006

January 1989

STRATEGIC HIGHWAY RESEARCH PROGRAM
LONG TERM PAVEMENT PERFORMANCE

Framework for Traffic Data Collection for the General Pavement Studies Test Sections

1.0 INTRODUCTION

The Long Term Pavement Performance (LTPP) study has six specific objectives. These are:

- Evaluate existing design methods.
- Develop improved design methodologies and strategies for the rehabilitation of existing pavements.
- Develop improved design equations for new and reconstructed pavements.
- Determine the effects of (1) loading, (2) environment, (3) material properties and variability, (4) construction quality, and (5) maintenance levels on pavement distress and performance.
- Determine the effects of specific design features on pavement performance.
- Establish a national long-term data base to support SHRP objectives and future needs.

The General Pavement Studies (GPS) experiment, one component of the LTPP study, involves the observation and monitoring of selected in-service pavement test sections over a period of up to 20 years. Each test section is a 500-foot length of one lane. The primary goal of the GPS experiment is to develop a national data base that will provide the data to meet the objectives of the LTPP study. Valid traffic data representing each specific section is vital in accomplishing these objectives. Traffic is one of the most important primary independent variables in a study of pavement performance. The quality of the traffic data has a direct influence on the ultimate results that can be achieved.

Many of the researchers who initially conceived the GPS experiment envisioned site specific traffic data being collected by low cost weigh-in-motion (WIM) equipment located at each GPS section. Unfortunately, low-cost and accurate weigh-in-motion technology has not yet evolved such that it can be recommended for every GPS site.

The limits of existing technology and the need to minimize the financial impact of a data collection plan without compromising the need for site specific data posed a significant problem for SHRP. In resolving this problem, SHRP sought assistance from two expert task groups (ETGs), one dealing with weigh-in-motion technology and the other with traffic data collection and analysis. Both of these groups included representatives from state and provincial highway agencies, universities and the Federal Highway Administration. In addition, SHRP contracted with Mark Hallenbeck to provide support to the two expert task groups. Mr. Hallenbeck is a research engineer with a strong background in traffic data collection from the Washington State Transportation Center and a co-author of the FHWA Traffic Monitoring Guide.

SHRP presented and solicited feedback on the main elements of the data collection plan at the fall regional meetings. A large number of constructive comments were received.

2.0 USE OF TRAFFIC DATA IN THE LTPP ANALYSIS

A principal objective of the GPS experiment is to evaluate and develop pavement performance models used to predict the future performance of existing pavements and to design new pavements. All pavement performance and design models require detailed knowledge of traffic -- both volume and axle load information. In design models, traffic is a primary input that dictates the thickness and strength of the required pavement structure. As predictive equations, these models predict the number of traffic loads that a pavement can carry. Thus, traffic data is an crucial variable in the study of pavement performance.

The traffic information needed to evaluate most existing pavement design models is the total number of 18K equivalent single axle load (ESAL) applications in the study lane. Due to differences in methods for computing equivalent axle load factors, the original axle load information used to compute these factors according to the particular design method is needed. This requires information on applied axle loads. It is desirable to have information on the weight and characteristics of all vehicle axles that have crossed a study lane from the time it was constructed. Alternatively, information on the number of truck axles grouped in axle load categories similar to those published in the FHWA W-4 tables would also allow equivalent axle load factors to be computed using different methods.

More detailed traffic information is needed for developing improved or new pavement performance models. The type of model that can be built is directly dependent upon the data that is available to the analyst constructing the model. The objective in planning for a study to be used in the future is to provide the greatest flexibility to the analyst by providing as much information as reasonably possible. The reasonable consideration applies both to the potential for the data to support an improved understanding of pavement performance and to the cost of acquiring the information.

With the development of mechanistic-empirical types of performance models, information on traffic loadings on a weekly or monthly basis allows an analysis and modeling of the effect of interaction between environment and traffic loading on pavement performance. For example, in freeze regions a large proportion of pavement distress occurs during spring thaw periods. Thus it is desireable to group traffic load applications into one-week or one-month intervals to permit development of this type of model.

Research has shown that the rate of traffic loading, such as ESAL/day, is significant in explaining the performance of pavements. The traffic data collection plan for SHRP needs to provide adequate data so that this parameter can be properly quantified.

Although most existing pavement performance models deal with structural considerations and only truck loadings, lighter weight traffic such as cars and light-weight trucks (< 10,000 lb) can influence the development of some forms of pavement distress, such as spalling, scaling, roughness, abrasive wear in the wheel paths, etc. Therefore, in addition to information on heavy vehicles, it is desirable to have data on the total traffic and the distribution of vehicle types traversing a test section.

In addition, pavement performance analysts and researchers could make use of the following vehicle-related information:

- Vehicle type
- Number of axles
- Axle spacing
- Axle weight (wheel load)
- Vehicle speed (loading time)
- Number of tires
- Tire type (radial, bias, studded)
- Tire pressure
- Date and time of vehicle crossing section
- Tire contact area
- Stress distribution across tire contact area
- Vehicle suspension characteristics (for modeling dynamic response)

Although interesting, it is neither feasible nor reasonable to measure and record all of these data elements for traffic on the SHRP LTPP test sections. SHRP's data collection plan is limited to the collection of the following information specific to each 500-foot-long, one-lane section that we are monitoring:

- Vehicle volumes crossing the GPS section,
- Vehicle classification (the make-up of vehicles in the

traffic stream), and
- The weight of the axles for each type of vehicle.

Besides its use in the pavement performance modeling, the traffic data collected on SHRP sections and stored in the national pavement data base will have other uses. Information on truck weight distributions and temporal variations will be useful for planning and as input to present pavement management systems at both the state and national level. Specifically, it could expand the sample used in the Highway Performance Monitoring System.

3.0 SHRP'S DATA COLLECTION PLAN

Long-term pavement performance analysis requires site-specific information on vehicle volumes, vehicle classification and axle weights. The data collected for each GPS site must pertain to that GPS site and cannot be a "system average." Although some traffic trends are probably fairly constant between similar sites, local changes in economic or enforcement activity can cause significant long-and short-term changes at some sites. The actual loadings at each GPS site are expected to vary significantly because of variations in the number of trucks, the types of trucks, and the weight of trucks between sites. Since the LTPP project is concerned with site-specific pavement deterioration, the pavement performance of respective sites must be well matched with the actual loadings impacting that pavement.

The ideal or preferred data for this analysis would consist of continuous weigh-in-motion data from the date of construction to the end of the analysis period for each GPS section. Unfortunately, this type of data base does not exist. In most cases, little traffic volume and classification information and, particularly, weight information has been collected at or near sites chosen as GPS sections. Even in future years, few states will be able to deploy and operate WIM equipment continuously at GPS sites. Thus the ETGs looked at a number of alternatives for sampling traffic volume and weights to minimize the amount of data collection without compromising the experiment. Financial limitations were the primary consideration in the development of the traffic data collection plan. The proposed data collection plan that follows outlines a preferred, a desirable and a minimum plan. The minimum plan generally provides the least-cost program that the two expert task groups recommended as being necessary to provide the required site-specific data to support the GPS program. In some instances, more data can be provided than requested by the minimum plan, for less or equal amounts of money. Such opportunities will be discussed later.

SHRP's proposed traffic data collection plan addresses two separate time periods or phases referred to as historic data and monitoring data. "Historic" or existing data refers to data that has been collected on or near the test section up to the time that enhanced GPS site-specific traffic data collection following the SHRP guidelines begins. "Monitoring" or new data is data collected on the GPS test sections following the data collection plan proposed by SHRP.

Since in-service pavement sections are being used as GPS sections, estimating past traffic is as important as collecting new information. The site-specific traffic information collected during the monitoring period will play an important role in the establishment of historical traffic data.

3.1 Monitoring Data Collection Plan

The monitoring data collection plan can be viewed as a three-level plan a "preferred level," a "desirable level" and a "minimum level." Continuous weigh-in-motion data from each GPS site remains the preferred or ideal level. Where continuous weigh-in-motion is not realistic, the "desirable level" data collection is suggested. The "minimum level" is an alternative for those extreme cases in which the desirable level is unattainable. Both these levels replace site-specific continuous weigh-in-motion with continuous site-specific automatic vehicle classification counts, short-term axle weight counts and regional weigh-in-motion sites.

Although the ETG's effort was directed at establishing the lowest acceptable level of monitoring period data to be provided for each GPS site, highway agencies are encouraged to provide more than the minimum where possible. Highway agencies may develop a strategy that employs a combination of the three levels on their GPS sections.

The desirable and minimum plans are outlined below:

i. Automatic Vehicle Classification: Automatic Vehicle Classification equipment, operating continuously for 365 days per year, should be installed at each GPS site by June 1992. Early installation and operation of the equipment would be preferred. Once installed, the AVC equipment should be left operating for the duration of the data collection period for the GPS experiment. If funding limitations are severe, a single year of AVC data is acceptable. The AVC equipment should provide data according to the FHWA 13 classification system. The requirements are summarized below:

Minimum	Desirable
1 continuous 365-day count completed by June 1992	Continuous 365 days/year operating by June 1991 for the duration of the monitoring period

ii. <u>Weigh-In-Motion Axle Weights:</u> Axle weight samples using weigh-in-motion equipment should be provided for each GPS test section for a one-week period during each truck season. A truck season is defined as a period of time during a calendar year when a significant change occurs in expected truck weights or volumes. The number of truck seasons will vary from location to location. For example, in agricultural areas truck weights for specific vehicle types may change several times during the calendar year as different crops are harvested. If information on the characteristics of local truck traffic on a test section is not known in sufficient detail to define truck seasons, then the short-term truck weight measurements should be performed on an environmental season basis, i.e. winter, spring, summer, fall.

Where the collection of one week of continuous data is not practical, SHRP will accept, as a minimum, the collection of one 48 hr. continuous count from the Monday to Friday period, and one 48 hr. continuous count from the weekend for each truck season. Collection of axle weights at each GPS site should be completed by June 1992. These requirements are summarized below:

<u>Minimum</u>	<u>Desirable</u>
1 Monday to Friday and 1 weekend 48 hr. continuous count for each truck season completed by June 1992.	7 day continuous counts for each truck season completed by June 1992.

iii. <u>Regional weigh-in-motion sites</u>: The minimum or desirable levels of site-specific data must be supplemented with information from a number of continuously operated regional WIM sites. These sites will provide information on temporal variations in vehicle classifications and weight. The regional WIM sites do not necessarily have to be located at GPS sites. The plan proposes that the regional sites consist of existing or proposed state operated weigh-in-motion sites supplemented with specially constructed new sites. The number of new sites will be determined by financial and technical considerations.

Work is underway on refining specifications for machine-readable submission of the traffic data. As a minimum, submission of this data will be made following the guidelines and formats contained in the FHWA Traffic Monitoring Guide. Descriptions of the vehicle classes used by the WIM equipment, and if necessary, the means by which the states convert those classes into the FHWA 13 reporting classifications will also be required.

3.2 Historical Traffic Data Collection

The plan for collection of historical traffic data is to acquire available traffic information from the participating highway agency along with a description of how the information was obtained and manipulated to represent different traffic statistics, such as average annual daily traffic and traffic loading. Because of the diversity in traffic counting procedures, equipment and analysis methods used across the United States, it is also desirable to access the raw data on which the reported traffic information is based. This approach will allow researchers to make decisions on the best use of the available data.

The data collection forms for historical information contained in the pre-implementation version of the LTPP data collection guide have been revised. An example of the revised forms are attached. These forms and the supporting narrative and instructions on how to complete them will become part of the SHRP data collection guide. They will be distributed to the participating highway authorities in the near future and discussed in a series of traffic workshops. Engineers from the SHRP regional coordination offices will work with individual highway authorities to complete these forms.

3.3 Schedule

SHRP's data collection plan will be implemented over a number of years. The implementation window for each of the SHRP data collection elements is provided below:

```
                    |--1989--|--1990--|--1991--|--1992--|--1993--
                    :        :        :        :        :
Historical inform-  :        :        :        :        :
ation to SHRP       :    |--------------------->        :
                    :        :        :        :        :
AVC installation    :|-------------------->    :        :
                    :        :        :        :        :
                    :        :        :        :        :
1 yr truck season   :        :        :        :        :
short term WIM      :|----------------------------->    :
counts              :        :        :        :        :
                    :        :        :        :        :
New regional WIM    :        :        :        :        :
installations       :   |----------------->    :        :
                    :        :        :        :        :
GPS site WIM        :        :        :        :        :
installation        :|-------------------->    :        :
(if applicable)     :        :        :        :        :
```

4.0 LOCATION OF THE REGIONAL WEIGH-IN-MOTION SITES

The regional WIM stations are intended to provide long-term information on seasonal and annual variations in truck loading and vehicle classifications that are applicable to groups of GPS sites. A decision on the location of the regional weigh-in-motion sites cannot be made until the majority of the GPS sites are finalized. Once the locations of the GPS sites are known, SHRP will assess the coverage provided by existing or proposed state continuous weigh-in-motion locations and identify those existing or proposed locations suitable for use as regional WIM sites and those supplemental locations necessary to alleviate gaps in coverage.

SHRP will contact highway authorities where existing or proposed sites that are suitable as regional WIM sites are located. If the highway authorities are agreeable, SHRP will designate the site as a regional site and have the data from these sites included in the data base.

Once the network of existing and proposed regional WIM sites is identified, SHRP will recommend new sites that must be constructed to fill gaps in coverage. SHRP will work with participating highway authorities to help coordinate the location of new regional WIM stations to meet the needs of both SHRP and the participating agency.

Recommendations on appropriate general locations of new regional WIM stations will include the following considerations:

- Locations and capabilities of existing traffic count and weighing stations, including ports of entry, enforcement stations, etc.

- Location of LTPP test sections. The stations should be located so that a maximum number of test sections can be directly covered by one station. Coverage consideration should extend across jurisdictional boundaries.

- Locations of major traffic generators, such as ports, manufacturing centers, regional distribution centers.

- Needs of local highway authorities, HPMS sections, planning needs, other research sections, etc.

- Location of other SHRP field test sections (Special Pavement Studies, bridges, ice & snow).

Once the general location is selected the following considerations will be used in determining the specific location:

- Suitable ancillary facilities such as electricity, telephone, right-of-way and other off-road features.
- Road profile characteristics (WIM stations need smooth upstream road profiles).
- WIM equipment installation requirements.

5.0 DISCUSSION OF THE RECOMMENDED PLAN

The traffic sampling plan developed for the SHRP LTPP study is a compromise between data acquisition cost and data needed to accomplish the objectives of the program. The need to limit the financial impact was an overwhelming consideration in the development of the minimum level of data collection.

5.1 Discussion of the Monitoring Plan

The preferred approach is a continuous permanent weigh-in-motion station located near the test sections. Ideally the station would be located close enough to the test section to measure the same basic traffic stream that passes the GPS test section lane. Although data is required for only one lane, the test site would be designed to avoid problems of vehicle by-pass caused by equipment placed only in one lane. To assure conditions conducive to accurate weighing, the site would meet the following specific criteria:

- it would be on the same highway as the GPS section,
- it would be weighing the same traffic stream, with no major interruptions to the traffic stream between the GPS and WIM site, and
- it would be installed a sufficient distrance away to avoid causing unusual dynamic forces on the 500' test section

In general all traffic data collection needs for the test sections can be met with continuous WIM equipment, as most WIM stations count and classify vehicles by number of axles and provide date and time information.

The desirable and minimum SHRP traffic data collection levels rely upon a combination of site-specific vehicle classification counts and short-term axle weight measurements supplemented with information from the regional weigh-in-motion stations. The regional continuously operated WIM sites will collect data that is representative of regional truck weight patterns. Data collected at these regional sites will be used at several GPS sites and, in many cases, at GPS sites in more than one state. It is hoped that the use of this combination of information will permit traffic estimates for each GPS site which are equivalent to information that could be obtained from a permanent WIM station at the site.

The concept behind the use of continuously operating WIM sites is to provide as much information as possible on the time variations in vehicle loads (axle loads), vehicle classes and traffic volume. The regional data will be used in conjunction with the site-specific weight and classification data to help estimate the actual annual wheel loadings for each GPS test site. Without a measure of seasonality at each site, short-duration weight information could provide misleading information concerning annual weights. The regional site data will be used to adjust the site-specific weights to represent average annual conditions, much as "master" traffic count locations are used for converting short-duration volume counts into estimates of AADT. For example, if vehicle weights in January are consistently lower than the annual average, then a factor might be developed to adjust short-term measurements performed in January.

The continuous classification counts at each site are designed to give a true measure of the actual annual traffic and provide information on shifts in the vehicle population over time (daily, weekly, monthly, etc.). Use of true annual traffic classification volumes without seasonal factors of any kind will markedly improve the estimate of total traffic volumes on a section. Information on the time variations and total volume of the different truck classes supplied by the automatic vehicle classifier will improve the researcher's ability to extrapolate short-term load measurements. Truck weight information can be extrapolated by truck class rather than across all truck classes. The vehicle classification information can be used to identify "truck seasons" or seasonal shifts in the heavy vehicle population and hence to assess and direct the short-term weight sampling needs for a section. Thus site-specific AVC information can also be used to establish seasonal factors that can be used to reduce the sampling effort in future years.

The seasonal short-term site-specific load measurements will provide the basic load data used to estimate the truck loadings on a test section. Although these short-term measurements do not provide information on how vehicle loads vary over extended periods of time, a reasonable estimate can be made by combining this information with information from the continuous vehicle classification counts and continuous weight information from the master WIM stations.

The proposed data collection plan is quite flexible for data levels exceeding the minimum. Many innovative opportunities are likely to exist for agencies to both reduce agency cost and provide improved information. As an example, piezo weigh-in-motion which has been demonstrated to perform well in concrete pavements, may in some concrete GPS sections provide a lower cost alternative than the AVC and short-term counts specified by the minimum level.

5.1.1 Limitations of the Monitoring Data

The SHRP data collection plan limitations occur primarily in the area of truck weights. Problems will result from differences between the various truck weighing installations and the use of short-term axle weight counts. Equipment and site characteristic differences of each GPS weigh station location will affect weighing results. That is, the same truck weighed at different sites will invariably exhibit different axle and gross vehicle weights. The size of this error will be difficult to define. Calibration information and site profile information will be necessary to address differences between scale sites.

As very few continuous weigh data samples exist, it is difficult to estimate the impact that trade-offs between site-specific, short duration weighing sessions and regional, long-term counts will have on the accuracy of the weight data collected for SHRP. Therefore, as part of the SHRP effort, the short-term data collected at individual GPS sites must be compared to the patterns shown in the 365-day counts at regional locations. If the short-term measurements, combined with the pattern information collected at the regional stations, are insufficient to provide accurate estimates of annual, site-specific weights, then additional weight data will have to be collected at each GPS site after the expiration of the current 5-year SHRP program.

5.2 Discussion of the Historical Data Collection Plan

Historical or past traffic on a site will be estimated using information collected from highway agencies via the historical data sheets and the site-specific information obtained during the monitoring period. The site-specific information is a cornerstone of this approach as it is used to form a baseline for traffic volumes, vehicle classification counts and axle weights. The limited historical data that is available can then be used to aid in "backcasting" the current estimate for each year from the baseline back to the year of construction or last overlay. The results obtained in this fashion will be significantly better than those achieved from using only the system-wide information, provided that the baseline data collection effort is sound. This is one reason why carefully taken site-specific measurements are necessary. In the absence of other information, research suggests that it is better to extrapolate from information collected at the site under study than from information collected on other sites.

Another important consideration in computing historic accumulated ESAL applications on a section is the predominant use of truck weight information collected using static scales. Research with weigh-in-motion scales has shown that static weight measurements do not adequately sample the heavier weight trucks, particularly overloads. This is natural, given the association of static weight operations with enforcement. Site-specific WIM measurements will be considered in factoring or modifying the historical weight information to better represent the number of overweight vehicles in the historic information.

5.2.1 Limitations of the Historical Data

Historical data submitted by the states will have a number of major limitations. The main limitation stems from the fact that little GPS site-specific information exists. This limitation is compounded by differences in data collection practices from state to state. Historical data is often based on short manual classification and weight sample counts taken in summer, with equipment of unknown accuracy, at static scales in an enforcement environment, for vehicles operating under various weight and dimension regulations. The significance of these differences varies considerably from site to site. The only means of estimating these errors will be by examining the site-specific information collected as part of the new data collection effort.

5.3 Coordination With Other Programs To Share Traffic Data

It is important that traffic data collection efforts be coordinated to the extent possible so that existing and new data collection sites are used effectively and efficiently. The traffic data collection for the Highway Performance Monitoring System (HPMS) appears at first glance to be a prime candidate for coordinated activity. Coordination opportunities exist, although the two data collection programs have been constructed to meet different statistical sampling needs. The HPMS data collection program acquires system-wide estimates of highway usage and vehicle characteristics based on a sampling scheme stratified by traffic volume groups and functional classifications. The HPMS system is flexible because of the multitude of uses made of the data. In contrast, the more rigorous SHRP data collection program is structured to provide essential traffic information specific to each 500 foot, one lane GPS section that is being monitored. The GPS sections were selected on an entirely different basis than the HPMS sites.

Although the two programs have no common basis, opportunities do exist to combine the two traffic data collection efforts. SHRP site-specific data could provide useful supplemental or replacement data for the HPMS. The HPMS sample data cannot however, support specific GPS traffic data needs. Each GPS site would have to be examined to determine whether it can become an HPMS site.

5.4 Sampling Opportunities and Statistical Confidence Limits

Sampling of traffic characteristics at each site could potentially reduce the amount of traffic data that needs to be collected and processed. A good sampling plan however, requires prior knowledge of the population being sampled in order to adequately establish the sample size. In most cases, the available traffic data at each GPS site is considerably less than would be necessary to develop a valid sample program. Collection of the data necessary to develop a site-specific sampling plan was considered as troublesome as collecting the requested data. Thus, the concept of sampling has only limited application to the LTPP effort.

Although desirable, it was not practical to specify the statistical confidence required from the data to be collected at each GPS site, for reasons similar to those presented above. Instead, the plan calls for a reasonable and consistent amount of information from each site.

6.0 EQUIPMENT

The data collection plan proposed by SHRP requires the use of automatic vehicle classification, portable weigh-in-motion and permanent weigh-in-motion equipment. Many different systems and suppliers are available for both the AVC and WIM equipment. SHRP does not have the resources to establish its own performance specifications for the equipment. SHRP will rely on the leadership shown by ASTM and the HELP program and adopt the specifications that they are developing. The HELP program specifications are expected to be released in the spring and the ASTM specifications are expected to be released in the summer.

In a March 2, 1988 memorandum, FHWA Executive Director Dick Morgan advised Regional FHWA Administrators that "the purchase of WIM and AVC equipment, using funds under Part I of the HPR program, will be allowed without match through calendar year 1990." Consequently, many states have expressed a desire to upgrade WIM capabilities more quickly than the SHRP plans anticipated. Some states had already planned a more rapid expansion of WIM capacity to meet their own need. SHRP also has limited funds to assist with the purchase of equipment. At the direction of the LTPP Advisory Committee, SHRP is developing a plan to use its funds to assist the states with the installation of the regional WIM stations.

6.1 Automatic Vehicle Classification Systems

The AVC equipment must be capable of measuring the number and location of axles on each vehicle and determining when or where one vehicle ends and another begins. The basic components of a system are as follows:

- i. Sensors, which provide data on the presence or passage of the vehicle to be classified;
- ii. Detectors, which receive and condition signals from the sensors and pass them on to a processor;
- iii. The processor, which performs the basic calculation of vehicle length, number of axles, etc., from which vehicle class is determined; and
- iv. The recorder, which stores the data and manipulates it into the presentation format.

Several different AVC systems exist. "Field Evaluation of FHWA Vehicle Classification Categories," January 1985, John Wyman, provides a good review of systems available.

SHRP does not recommend a specific type or brand of AVC equipment. Uniformity of approach to classification equipment is not essential within SHRP. Where new equipment is required, states are asked to assess the relative merits of the different equipment in regards to their own program in deciding on the system(s) to deploy. SHRP recommends that AVC equipment be able to classify vehicles into either the 13 FHWA vehicle categories (scheme F) or a more detailed classification scheme defined by individual states that is compressible to the 13 FHWA categories.

In general, AVC equipment considerations include cost, ease of installation and the reliability of the sensor, and cost, classification accuracy, counting accuracy, reliability and durability of the electronics.

Equipment and installation costs vary considerably. Two examples are provided below:

		Wisconsin	California
2-lane	Equipment and Installation	$11K	$16-20K
4-lane	Equipment and Installation	$16K	$32-40K

6.2 Weigh-In-Motion Equipment

Weigh-in-motion is an established but evolving technology. The different systems available for performing weigh-in-motion have a wide variety of different characteristics, strengths and weaknesses. These systems employ a variety of technologies including:

- Bending plate systems,
- Shallow weight scale systems,
- Deep pit weight scales,
- Bridge systems,
- Piezo systems and
- Capacitance systems.

SHRP does not recommend a specific type or brand of WIM equipment. Uniformity of approach to WIM equipment is not essential within SHRP. Where new equipment is required, states are asked to assess the relative merits of the different equipment in regards to their own program in deciding on the system(s) to deploy. Equipment meeting the accuracy specifications of the draft ASTM and/or HELP demonstration project is adequate for SHRP. It is important to keep in mind that the accuracy of the equipment is not simply a function of the technology of the WIM device and the brand of equipment. Site conditions play an important role in the accuracy of a system. Pavement profile and condition is probably the most important external factor.

A large number of reports and conference proceedings on weigh-in-motion can be found in transportation literature. A number of the commercially available systems have been evaluated by highway agencies, the FHWA and others. WIM systems evaluated in the HELP program include:

System	State
Bridge Weighing Systems portable	Oregon
Golden River portable	Idaho
International Road Dynamics permanent	Oregon
PAT permanent	Texas
Radian Corporation semi-portable	Texas
Streeter-Richardson portable	Texas
Streeter-Richardson permanent	Illinois

Quite a wide cost range exists for weigh-in-motion equipment. Portable capacitance pad equipment costs in the order of $35,000, Piezo installations in the order of $20,000, Bending plates installations in the order of $40,000, and deep pit equipment in the order of $200,000. Installed costs are highly dependent on local conditions.

6.3 New Equipment

New automatic vehicle classification and weigh-in-motion equipment is under development and testing. Traffic data collection system vendors and public agencies are pursuing new sensors and electronic components. Work on sensors includes:

- Permanently installed axle sensors, using piezoelectric

cable, piezoelectric film, and triboelectric cable;
- temporarily installed axle sensors, including tapeswitches, piezoelectric film strips, and piezoelectric cable;
- Temporarily installed vehicle presence sensors, including both portable and disposable inductive loops;
- Permanent WIM sensors, using both established and new technologies; and
- Portable axle sensors using both established capacitance mats technology and new piezoelectric film and fiber-optic technologies.

Advances in electronic components are centered on the rapid evolution of microprocessor technology. Microprocessor capability has greatly improved; at the same time, energy consumption requirements have decreased. Sophisticated systems powered by batteries are being developed.

Some of the new equipment may be available during the SHRP program given the long implementation period of the SHRP data collection plan.

7.0 CONCLUDING REMARKS

Traffic data collection to support the GPS experiment is a very complex and difficult issue. In developing the data collection plan, SHRP was very sensitive to the financial implications of traffic data collection for highway agencies. As a result, automatic vehicle classification combined with short-term weighing sessions were substituted for continuous weigh-in-motion data, and the minimum level of data that would not compromise the experiment was identified.

SHRP will conduct a series of workshops to further discuss traffic data collection requirements and capabilities on or before June, 1989. Where practical the workshops will be held in conjunction with FHWA's "Application of the TMG" course.

January 11, 1989