全国経済委員会報告汇編

第五集

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全國經濟委員會報告彙編 第五集

第七次國際道路會議中國報告

中華民國二十三年二月

全國經濟委員會叢刊第十二種

中華民國二十三年二月　第七次國際道路會議中國報告

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引言

國際道路會議，肇始于一九〇八年，其第一次會議在法國首都舉行，國際道路協會即因是產生。其會所亦設于巴黎，協會最大之任務，爲籌組會議，迄已舉行六次，每次會議，例由協會規定議題，先期分發有關各國編送報告。本年九月三日，第七次會議舉行于德國孟尼市，其規定議題有六：

一　討論自華盛頓國際道路會議以後，各處應用水泥築路之成績，須於經濟及路面防滑方法兩方面特加注意。

二　討論自華盛頓國際道路會議以後，各處製造及應用柏油，瀝青乳化油，以築路養路之成績，惟一面須注意可以節省結合料用量之所用方法，及機械設備；一面須注意於路面防滑之方法。

三　討論在經濟狀況之下，城鄉路面建築與修養之有效方法。

（一）所採之方法。

（二）研究因土壤及氣候之各種性質所能影響於選擇築路養路方法之條件。

四　討論關於在城市鄉間，及鐵道平交道等處，應行採用運輸安全保障之方法；如法規，規則，及標誌等項。

五　從運輸經濟之立場上，研究車輛交通與路面之關係，並討論各國在技術上，法規上，及管理上，所規定對於減少各種行車損害之方法（如震動喧鬧等項）。

六　（a）提出關於下列各項現行規則：

（一）關於限制車輛之載重者（實車或空車）。

（二）關於限制車輛及其所載貨物之闊度及高度者。

（三）關於限制車輛及其所載貨物之長度者。

(b)詳細批評此項規則所發生之利弊。

(c)討論此項規則，是否有各國劃一之必要。

倘屬需要，宜以何項原則爲劃一之標準。

本會於二十二年夏，接准外交部轉送前項議題後，即由本處撰擬報告，並一面分函各省市路政機關，暨專術團體，徵求報告資料，由處彙編，爲代表吾國之整個報告凡五種。原文以限於會章，用英文，茲將是項報告，譯成中文，附同各方所送報告撮要一併刋行，藉供關心路政者之參考。倘蒙海內明達，不吝指教，至所欣幸。全國經濟委員會公路處誌。

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37

目錄

撰述者名單

報告一	全國經濟委員會公路處技士	張昌華
	漢口市政府技士	蔡鉉
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	全國經濟委員會公路處技士	張昌華
報告三	湖南省公路局總工程師兼科長	周鳳九
	上海市工務局技正兼科長	薛次莘
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	全國經濟委員會公路處技士	張昌華
報告四	全國經濟委員會公路處技正兼科長	康時振
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	浙江省公路局營運科科長	曹壽昌

報告六

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上海市公用局技正兼科長　張登義
漢口市政府技士　劉以鈞
全國經濟委員會公路處技士　王總善
蘇浙皖京滬五省市交通委員會副工程師　徐安

編送第七次國際道路會議報告簡則

國際道路協會永久委員會公布

（一）入會國對於所預定之議題，不得提出一個以上之報告。但每一議題之報告，得由數人共提之。各個報告，均須設法殿以明晰之結論，俾總報告員（提案審查員）易於就特殊問題之各種報告中，提出總結論於大會。

（二）所有報告均須於一九三三年十一月十五日以前寄交本會祕書長，不得延遲。（按此節已展限至一九三四年三月一日以前）

（三）報告所用之文字，可於英法德三種中任擇一種。每一報告，應共寄三份，并祇可繕寫於一面。報告需要三份，係供祕書長同時譯印為三國文字之用；設著者自願譯就亦可。

（四）各個報告應注意事項：

（a）文長　每個報告，不得超過八千字，即每頁印四百字，以二十頁為度。但第二議題，因特殊情形，可達一萬二千字。

（b）文中之示圖及照片　若示圖所佔之總篇幅，不超過五十平方吋，則其數目可至六幅。

（c）正文外之附圖　應於正文外另行印製之示圖（設計圖或照片）限於二幅；每幅之大小連圖線在內，不得大於9"×18"。

註—因求清晰起見，除照相圖外，所有示圖，應以黑綫繪於摹圖紙或摹圖布上。

（五）若一報告係數人合著者，可自相協定，或以數人之名，提出一連合報告；或由各著作人，於其所著各章，分別簽名，悉聽其便。在第二種情形中，各章之長短，由各著者自行商洽。設有異議時，凡曾組織委員會之國家，即由委員會決定之；在無委員會之國家，則由該國出席國際大會之首席代表決定之。但無論如何，均須遵守第四條所規定之範圍。

注意　第二節所限日期，不得逾限，因各種報告均須譯成數國文字，並須印成數國文字，又須將各個問題製成總報告，於開會前兩個月，分發各會員研究也。

報告一　華盛頓國際道路會議以後各處應用水泥築路成績之概述

引言

水泥在中國已經用作市街公路路面及瀝青路路基之建築材料。現在公路運輸量尚極小，用水泥建造公路，雖不合經濟原則，但就各種高級路面材料而言，水泥用途實具有日見廣大之希望。南京近郊之第一試驗路，其中有一大段，即係用水泥築成，藉以研究其用作公路路面之適宜性爲若何。該路由全國經濟委員會公路處於一九三二年築成之。工程上頗多創見，蓋求其切合經濟原則也。全路概用人工築成，現通車已逾一載。但尚有數方面須經充分時間之試驗，始可作最後之結論也。本報告書概就試驗路面言，對於國內他處之實施情況亦間及之。

（一）路面之類式

試驗路之用水泥建築者，共有十四式。總長八〇〇公尺，每式長五〇或一〇〇公尺不等。茲依其建築方法，可簡括爲下列三類：

1. **水泥混凝土路**　分單層路面與設計不同之雙層路面二種。有不用嵌筋者，亦有用竹條爲嵌筋（Reinforcement）者。

2. **水泥結碎石路**（Cement-bound Macadam）　曾試用下列三種方法建築此類路面：（a）乾和法（Dry Mixture Method）；（b）灌漿法（Penetration Method）；（c）夾築法（Sandwich Method）。

3. **水泥混凝土車軌**　築水泥混凝土車軌二條，兩旁及中間鋪彈石路面。所用水泥均波德蘭水泥，皆國內用濕法或乾法所製成之產品。粗混料係堅硬之石灰石及石英石，細混料則爲經揀選後之河沙。

水泥混凝土路面之概述

路床——築造路床時，須特別注重其勻整一致，並改良排水方法，即於路肩之下，埋置直徑大八公分之竹管，自路面底層傾向路基外邊透出，導水洩入邊溝中。

橫斷面——各式路面均寬五公尺半，路冠爲一比五〇，其他部份略有互異之點。爲比較計，築有標準路面一段，所用混凝土混合比爲一：二：四，其厚度（Uniform Thickness）一律爲十八公分，材料之配合概以體積計算，取其設備簡單，實施便捷也。橫斷面之設計可分爲下列三大類：

a. 等厚單層路面（Single Course Slab）——路面等厚爲十八公分，有用縱伸縮縫者，亦有不用者，內有數段曾於單向或雙向用竹條爲嵌筋，其詳細情形將於嵌筋一節中述之。混凝土混合比分用一：二：四及一：二：五兩種以資比較。

b. 厚邊單層路面——此類路面優點，在所需材料較爲經濟，角隅之破裂亦較鮮見。試驗路中築有一八—一三—一八式數段。或有用縱伸縮縫者，或有不用者。路面兩邊厚度爲一八公分，由路面每邊起向路心直至距外邊六〇公分處止，路面厚度逐漸減少至一三公分。凡有縱伸縮縫者，則以短竹條爲合縫釘（Dowels），橫貫縫中。每邊路面沿邊處，各置縱竹筋一條。關於伸縮縫詳情，當於縱伸縮縫節中再述之。

漢口市所築之混凝土市街路面，係用一七—一二—一七式之橫斷面，無嵌筋。利用舊碎石路爲路基。築有齊頭式（Butt Type）縱伸縮縫，無合縫釘，但將鄰近縱伸縮縫兩邊之路面加厚，故修造路床時需工較多。

c. 雙層路面——雙層路面採用等厚斷面，共厚十八公分。面層厚八公分，用一：二：四較濃厚之混合；底層厚十公分，用一：三：六之混合。蓋稍厚路面之上下面溫度不一，厚薄之混合物，漲縮係數不同，每易發生隆起及皺折現象，因致路面破裂，用上述方法，裂可減免此弊。底層之上鋪油紙數層，以減少面底二層間接觸面之黏結力及摩擦力。

縱伸縮縫——路面設縱伸縮縫者共有三式，伸縮縫均爲齊頭式，縫間填以桐油浸透之厚氈，二式有合縫釘，橫貫伸縮縫以聯穿兩邊路面，位於路面底面之上約五公分處。沿伸縮縫每公尺貫三釘，釘爲竹製，直徑大三公分，長九〇公分，一端固埋於一邊路面，他端

則裹以油紙，埋置於另一邊路面，俾路面有伸縮時，竹釘得自由移動於紙裹間。至關於竹料之性質，當於嵌筋一節中詳述之。

橫伸縮縫——路面每間二十五公尺設橫伸縮縫一道，其中每隔十二公尺半，另有建築縫(Construction Joints)一條。縫爲齊頭式，或於路面下置有托樑者。縫間多塞以油氈，油氈之伸縮性尚佳。

嵌筋——嵌筋概爲竹製，其安放方法共有三種，於厚邊路面中，凡邊沿處均各置竹筋一根。路面僅設橫向嵌筋者，則竹筋之間隔距離爲二〇公分；若併用縱橫二向嵌筋者，則每隔八公分加縱嵌筋一根。如厚十八公分之路面，所用嵌筋爲一公分至一公分半見方之竹條，安置離路面底以上五公分之處。

竹筋斷面爲方形，係由粗肥竹竿劈剖製成。竹之爲用雖多，但以之充路面之嵌筋，尚屬創舉。因此會舉行各種試驗以決定竹之物理性質，計試驗抗彎、抗剪、彈性、抗拉、抗壓等力量，先後共達二百二十次。試驗最大抗拉力時，係採用試驗鋼筋混凝土之同一方法。各種結果如下：

最大抗壓力	5,500磅/平方吋		388	公斤/平方公尺
最大抗拉力	14,000	,,	986	,,
最大抗彎力	13,000	,,	915	,,
最大抗剪力	450	,,	31.7	,,
彈性係數	1,660,000	,,	116,900	,,

因竹筋各種性質尚屬適宜，且其價值較諸鋼筋低賤殊甚，用作混凝土之嵌筋，堪稱物美價廉。惟尚有二點須待考察，即竹質腐敗之遲速，及其伸縮時對於在混凝土間固結應力所生影響爲何如耳。總之試驗路對於竹條用作混凝土路面之嵌筋，其價值若何，行將有以闡發之。

路面之現狀——水泥混凝土路面之近況，大體尚佳。全長五〇〇公尺中，僅有裂縫數處。內中二處顯係角隅裂縫，一處爲縱向裂縫，另

一處爲橫向裂縫。

所有角隅裂縫均發現於厚邊式之路面上，其有二處：一處發現於縱橫二伸縮縫之交錯處，該地路面厚十三公分；一處發現於距路緣八〇公分處，逐漸延及角隅，幸使路面損壞。但此二裂縫均發現於填土之處，顯見十三公分厚之路面在新填路基上，對於目前之車運尙難勝任。縱向裂縫發現於雙層路面，其原因似爲面層厚度不足所致。橫向裂縫發現於第二十七式路面中，該式爲一：二：四混合之路面，厚十八公分，縱橫二向均有竹筋。

（二）水泥結碎石路

因水泥混凝土路之造價過高，不得已而求其次，乃建水泥結碎石路以爲試驗。此式路面曾試用三法建造，以夾漿法之結果較灌漿法及乾和法爲優。但三者均尙不足勝任目前之運輸量，據運輸測量之統計，平均每日約有汽車三百輛，牲口約四百頭，經行該路，車輛中有半數係重載貨車。一月之中，間有十數軍用雙鐵輪車及爬齒式唐克車經過一二次。

夾漿法在試驗中成績雖佳，但仍以灌漿法施用爲廣。碎石路之灌漿須滲透均勻，此爲預防路面局部凹陷（Flat Pot Holes）之要點。泥漿之混和宜稍濃厚（rich），其稠度須適合於自由灌透路層隙縫，並使沙與水泥固凝不散。試驗路中所用水泥與沙之混合比爲一：二；漿口所建之中山路曾用一：一之混合，該路係於一九三三年建成，路基爲舊日之碎石路。

乾和法之得名，蓋由於建築時使用水泥和沙之乾混合物也。此法可用一：三較薄之混合，但灌入不深，爲此法之固有弱點，故路面不久即呈破壞形狀。

夾漿法試用後，結果頗佳。所用混合比例，均爲較薄之一：三及一：三·五，其法以水泥漿澆於基層之碎石上，再鋪五公分碎石一層，以機滾輾壓之，至面層碎石中有泥漿透出爲止。

此法試驗結果，與薄水泥混凝土路面相同。頗能適應現有之運輸情形。及至最近，該式路面始有少數橫向裂縫發現。

（三）混凝土車軌

以水泥混凝土作車軌，亦試驗中一種饒有意味之路面也。軌寬九〇公分，厚十八公分，爲無筋之一：二：四混凝土二軌內沿相距七〇公分，每隔二五公尺，設伸縮縫一道。每二伸縮縫間，再有一建築縫。

車軌內外均鋪以彈石塊，路面雖相糙不光，但殊堅實耐久，尤利排水。如遇往來車輛偶因讓道行駛於上，亦頗平穩，僅覺車輛稍有震動耳。

路床用竹管排水，如何安置，詳見斷面圖。附工程攝影二幀：其一表示正在建造時之情形，其二則表示鋪加彈石路面後之情狀也。

此路段已通車一年有餘，汽車駛行其上，舒適迅速。行車費，建築費及養路費等，均頗經濟。除一軌因路基填土下沉，致現橫向裂縫外，其餘現狀均佳。

前舉各式路面之平均造價，包括人工用具一應在內，茲列表比較如後，工價約佔總數百分之七。

（一）水泥混凝土路	每平方公尺	三・九〇元
（二）水泥結碎石路		二・三〇元
（三）混凝土車軌		一・九〇元

結論

（一）水泥在國內用作公路路面建築材料日漸普遍，而公路交通之發達，又有一日千里之勢，今後水泥之於道路工程，其用途正未可限量也。

（二）若有堅硬之粗混料可資採用，即運輸量雖大，載重不一，仍以採用單層水泥混凝土路面較諸雙層爲經濟。

（三）另加瀝青層於混凝土路面以爲磨蝕面，似非必要。

（四）水泥結碎石路若無磨蝕層，對於車輛通行恐尚不能抗應裕如，但經行運輸量不重，仍可設法改良，使成一種經濟之路面。其

建築方法，似宜採取夾漿灌漿二法，加以研究而改良之。

（五）混凝土車軌路面與混凝土路面相較，費用甚省。如在常年能通車並須車輛行駛舒適之地域，而其道路之運輸量在最近期內不致需要建築二車道之全路面時，則以採用此式車軌路面爲最適宜。惟所應注意者，車軌間及其兩旁必須鋪有一種堅實耐久利於排水之路面，如彈石路面，始足相得益彰。

（六）厚邊水泥混凝土路面，對於角隅抗力之保強頗有效驗，但路面厚度漸次向路心減少，不可稍越該路通行運輸量所需之限度，俾能勝任裕如。

（七）縱伸縮縫對於不規則縱向裂縫之防止，尚著成效，並能用作車輛行駛時之導綫。

（八）混凝土路面之路床，當與其他路面之路床同樣注意其堅實勻整。人工與機器工成績幾可比美，凡在失業成爲嚴重問題或勞工低廉之處，大可利用。

報告二　華盛頓國際道路會議以後各處製造及應用柏油瀝青乳化油於築造路面及養路成績之概述

引言

中國之汽車運輸日漸發達，瀝青材料用以建築及修養道路亦漸廣，此種路面之里程大都集中於各大城市，近更有向近郊逐漸伸展之勢。建築時多參考前人之方法，並就當地情形酌加改良，工程上尚無何等困難，惟近來瀝青路面之需用愈亟，應如何利用瀝青材料，方合道路修築上之經濟原則，已成爲刻不容緩之問題。全國經濟委員會建築第二試驗路及上海特別市工務局之設立冷拌廠與瀝青材料實驗室即本此意。結果如何，當爲國內道路工程司及市政工程司所樂聞也。

瀝青材料用於中國道路建築者，現僅限於下列數法：

（1）土路，泥結碎石路，及水結碎石路之路面澆油（Surface Treatment）。

（2）灌瀝青碎石路。

（3）熱拌瀝青路面，例如土瀝青沙路面（Sheet Asphalt），及土瀝青混凝土路面（Asphaltic Concrete）。

（4）冷鋪瀝青路面。

關於築路材料規程及施工細則，茲不贅述，蓋與歐美各先進國採用之方法類同也。

（一）路面澆油

瀝青材料在中國曾用以澆鋪於土路與泥結碎石路及水結碎石路之表面上，但泥結碎石路之用此種處治法實屬創舉。一方面求碎石路能適應現代之交通狀況，他方面希望里程增長時，費用不致隨之劇增，故中國各省均將水結碎石路改築泥

結碎石路，其造法與灌瀝青碎石路相同，不過前後二次均用泥漿代瀝青耳。泥之最大効用，乃在襯托粗混料，以吸收車輛衝擊時所生之震動，使粗混料固定。泥之强大黏結力，與粗混料之互相鑲嵌，頗能承載高速車輛之剪力；但不另加磨蝕層，則經風雨之侵蝕，結合料逐漸裹失，路面隨之敗壞。是以全國經濟委員會公路處於南京築有第二試驗路以試驗柏油、土瀝青及瀝青乳化油之效用。成績頗佳，可於下圖見之。圖中係五公尺半之泥結碎石路，上加二・八公尺之單層路面澆油；否則路面將破壞殆盡。

泥結碎石路之路面澆油於通車後其表面呈摩賽克（Mosaic）形時澆之。澆油一次，每平方公尺用油三公斤，或澆二次共用油四公斤半。所有窪洞，須於澆油前，挖成方洞填滿夯實之。施工細則與水結碎石路之路面澆油同。

（二）灌瀝青碎石路

凡建造熱拌土瀝青混凝土路，須另建拌和廠而費用浩大者，與交通情形需要此種高級路面者，近來各地多有改築灌瀝青碎石路之勢。第一次灌漿多爲四十至五十貫入度之土瀝青，每平方公尺約用八・一公斤。上鋪石屑輾壓之，再加封面一層，每平方公尺以用瀝青四・二公斤爲度，用橡皮刮刮勻後，撒石粉一次，俟車輛將通行以前，再加末次輾壓。

（三）熟拌瀝青路面

所謂熟拌瀝青路面，係指土瀝青沙路及瀝青混凝土路而言。大多建於城市中，因拌合廠設備殊多靡費，而施工時尤宜格外小心，故上海現正試用冷鋪法。

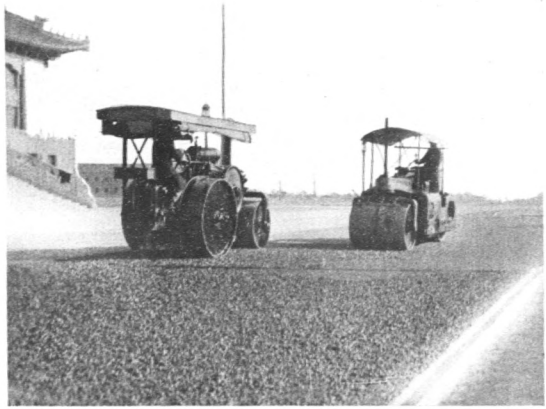
（四）冷鋪瀝青路面

上海現今所造之冷鋪瀝青路面，通稱爲『冷拌瀝青路面』，主要成份爲石料及冷熔劑，外加定量之天然土瀝青粉，及石灰石粉。路面之鋪築常分二層，混合成份，各不相同。底層用粗石料，面層用細石料。冷熔劑則爲精煉柏油，土瀝青及輕柏油之混和物，或僅含土瀝青及輕柏油而無煉柏油者。茲將此二法所製成之熔劑，列其性質於後：

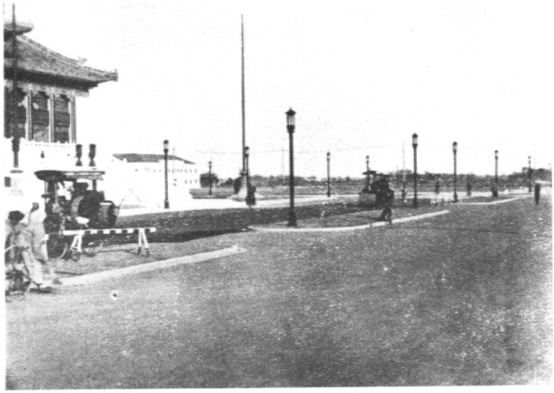
	第一法	第二法
a. 比重77°/77°F	1.165—1.200	1.207
b. 引火點	120°F—130°F	239°F
c. 揮發性	4—6%	——
d. 固定碳量	30%	9%
e. 灰	2.5%	0.5%
f. 瀝青總量(溶於CS_2)	80%	99.0%
g. 溜解度		
含水量	——	微
0°—200°C	1.25%	1.4%
200°—270°C	11.50%	10.0%
殘渣	——	88.6%

并和時先將石粉倒入混合器中，次將預先起泡之瀝青加入，再次將土瀝青粉加入，最後將石粉加入。其比例如次：

面層：	細混料		86%
	冷熔劑	6/10—7/10	8%
	土瀝青粉	4/10—3/10	
	石粉		6%
	（冬季應加液化油爲冷熔劑之13%）		100%



冷拌柏油石子路建築時攝影



冷拌柏油路完成後之攝影

底層：

粗混料		91%
冷溶劑	6/10—7/10	5%
土瀝青粉	4/10—3/10	
石粉		4%
（冬季應加液化油為冷溶劑之15%）		100%

液化油為輕柏油與汽油混合而成，於石料傾置拌機後加入之其作用在製成一種能合於寒冷天氣應用之混合物也。拌廠設計詳見另圖，所附之照片乃係該廠之內部情形。

拌機之旋轉率約為 30 R. P. M. 於夏季每隔二分半至三分鐘可出料一次，約四分之一公噸。冬季則須四五分鐘左右。

築路法

『冷拌瀝青』鋪於路面中層為碎石或碎磚，下層為大石塊路基。若車運繁盛之區，中層亦有用水泥混凝土者。路面之厚度不一，苟壓實厚度定為五公分，則底層鬆厚五・六公分，面層鬆厚二公分半。若所定壓實厚度為三・八公分則底面各鬆厚四・四公分及一・九公分。在前一例中，每混合物一公噸可鋪路面十二平方公尺。每平方公尺約值價二元一角；在後一例中，每公噸可鋪三十五平方公尺，每平方公尺值價一元七角，材料工資及用具各種費用，均概括在內。

混合物自廠中用運貨車裝至工地，然後傾注於路上，刮平之以達規定之厚度，每層均宜各自輾壓堅實。壓法先以七噸重之二輪輾路機滾過，再以十噸之三輪輾路機隨後加壓，最後以七噸重之二輪輾路機復壓一次，俟面層已壓實之後，撒石粉一層結面。每立方公尺石粉約鋪路面三〇〇平方公尺。將石粉掃勻，然後再施輕壓一次，即可通車。路面完成後，狀如鍔皮。

『冷拌瀝青路面』之造價，較其他瀝青路面均為低廉，惟不及澆瀝青之碎石路路面而已。下表所列，係根據一九三三年上海之市價編成。

路面種類			每平方公尺之造價
面層	中層	路基	
五公分土瀝青砂路	二十公分水泥混凝土	二十五公分大石塊	$ 10.40
上全	十公分水結碎石路	全上	7.10
五公分瀝青碎石路	全上	全上	4.90
五公分冷拌瀝青石子路	全上	全上	4.70
四公分八冷拌瀝青石子路	全上	全上	4.30
路面瀝油每平方公尺用4磅	全上	全上	3.25

若路基改用碎磚，則造價可減少六角。

結論

（一）泥結碎石路之瀝青處治，若瀝鋪帶時（即路面呈龜裂者亦然），並修窄帶法，則結果頗佳，其帶改良現有泥結碎石路之一種經濟方法。

（二）瀝青乳化油用作泥結碎石路或水結碎石路之路面灑油，成績尚堪讚許。蓋施工簡，費人力亦，陰雨天氣亦能工作也。乳化油所處治之路面，現粗糙狀，亦可以防滑。

（三）冷拌瀝青路面造價低於熱拌瀝青路面，所省瀝青達百分之三十五。拌和廠之設備簡單，運路方送亦簡便。無論天氣寒冷微雨或路面潮濕，均可施工。雨濕時路面之滑度小，倘壓實合度，修整及時，足以供給交通緊盛之需要。

報告三　城鄉經濟路面之建築與修養方法之概述

（一）採用之方法

（二）土壤與氣候影響選擇方法各條件之研究

引言

利用當地材料以建造廉價之路面，在國內各處所築類式頗多，而最盛行者有二種：一曰彈石路，二曰泥結碎石路。

彈石路面與卵石路面相似，所用路面石料爲敲就破片石塊，大至十公分至十五公分，並有襯墊一層，通常亦有築路基者。此種路面效用之優劣，全視工人之鋪砌技藝如何，因所用之石塊多參差不齊也。設法改用形式較爲整齊之石塊，而不致過於增大其價值，乃爲今日之要圖，於是有試建半整齊石塊路面之舉。全國經濟委員會所築此式試驗路，結果認爲造價所增無幾，而成效頗佳。

泥結碎石路係自水結碎石路蛻化而出，自後幾已取而代之。以原理言，泥乃結合料，並爲粗泥料之裹襯物。但顧名思義，即可知泥結碎石路抗應通行車輛之能力，未必較水結碎石路爲優。而泥結碎石路之所以盛行一時者，取其保養廉易，效用耐久，而於交通較繁之區，亦尚可勝任裕如也。

全國經濟委員會所築該式試驗路，日有汽車三百輛，牲口四百頭行經其上，一年以來，尚未加以修補。現狀仍佳。而他路設有巡道隊隨時加以保養者，其能保持常態之期間，尤較久長。

彈石路與泥結碎石路，在國內雖爲市街及公路上最普通之路面，但築路方法及採用材料則各地迥不相同，考其原因，不外材料之供給，氣候之變化，交通之狀況及土壤之性質，彼此各殊也。至對於各不同條件，究應採取何種方法及材料爲宜，則概無詳細定則，可資考察。一九三三年全國經濟委員會爰於南京築第一試驗路以供研究，內有彈石及半整齊石塊路面七式，總長五三〇公尺；

泥結碎石路面四式，總長四七〇公尺。

本報告書僅就上面提及之三種路面，予以簡要之敍述，而歸納於以下二題內：

（一）彈石路與半整齊石塊路

（二）泥結碎石路

（一）彈石路及半整齊石塊路

彈石路面——彈石路面係一種單葦式路面，具有此種路面固有之優點，其修補簡易而又經濟，蓋可以逐塊取換，毫不阻礙交通，原有路面之剩餘價值亦大。倘即以不加修整之粗石塊爲路面材料，其價值之廉，更非其他同類路面所能比擬。在多雨之區，泥路苦其濘滑難行，改建彈石路面，足供應中等以上繁盛之交通，終歲暢行無阻。

半整齊石塊路——彈石路所用之粗劣石塊，成績尙欠優良，因路面過於粗糙，車輛震動甚烈，聲響刺耳，行車耗費既大，乘客亦感痛苦。苟面石之形式不加修整，雖有良好之路基，宣暢之排水設備，亦不免有事倍功半之譏。此第一試驗路中所以試用半整齊石塊也。較之彈石路之造價，所增無幾，大有推行之可能。

路面設計——無論爲彈石路或半整齊石塊路，通常均有路基及墊層。石塊路面壓實厚度自十公分至十五公分，墊層厚五公分至十公分，路基厚八公分至十五公分不等。下表所列係各地設計上所用之標準：

路面之種類		厚度以公分計		
		面層	墊層	路基
彈石	上海	10	10	15
	南京	10	5	12

路面	浙江							
半整齊石塊路面	無委會第一款	10	4	8				
	無委會第二款	13	5	—				
		10	10	10				
		15	5	15				

有一點堪足注意，苟路床堅實，交通不繁，如江蘇所定之標準，即可不用路基。惟路面之兩邊緣，宜用較大之石塊鋪砌。

材料——路基材料或爲碎石或爲碎磚。墊層可用當地出產而性質適宜之材料，大都不外河砂，山砂，煤屑，石屑等。但各種材料，均須質地均勻優良，不含雜質。路面石塊可用石灰石，砂石，石英石，花岡石，或其他附近出產之岩石，經負責工程司認可者。

彈石路之石塊，無一定之形式，但上下二面均須平整，彼此略作平行，庶使底面置於路上，不致傾斜過甚。石塊雖不必逐塊細加修整，亦宜將四周之有凹凸部份者，大致敲齊，則鋪砌接縫，不致過寬，受重時，亦不致有動搖之弊。

半整齊石塊之頂，須大致修成方形，頂底二面，務須求其平整光滑，彼此略作平行。底面之大小，不能小於頂面十分之六。旁側不能有任何一面與頂面成大於三十度之角度。石塊任何面不能有凹凸崢嶸之狀，頂面上局部高低，最多相差五公厘，四周則限於八公厘。而任何一面之尺寸，不能大過或小於規定大小至一公分之多。

彈石及半整齊石塊之普通厚度，約爲十公分至十五公分。每塊之長與闊，不能大於十五公分。（半整齊石塊之頂面，最好能成十公分之方形。）鋪砌時應將石塊長度之方向，與車道中線成垂直縱向接縫，宜彼此參錯。

路面兩邊緣，通常均以較大之半整齊石塊鋪砌。石塊之厚，應大於或等於中間鋪路之石塊，約厚二十公分，長二十五公分。

建築方法

路基——用碎石或碎磚爲路基，厚八公分至十五公分。若雨量甚多，路床土質不堅之區，路基之厚度，尙須加大。南京第一試驗路所用之路基爲十公分，已覺適用。該地之路床，係淤沙性黏土，乾燥時載重力頗強。路旁並埋設竹筒排水管，詳見附圖。

此式路中曾有一段，初築時未用路基旋路面發生波紋形狀，後經重行翻造，另加十公分之路基，排水不良，實爲失敗之主因。惟試驗路以外之京杭路各段，亦有全無路基者，而通車結果則尚佳。

墊層——路基築成之後，上鋪山沙、煤屑或石屑之墊層。各種材料，均以六公厘之眼篩篩過。若厚度規定爲十公分時，宜用輕滾輕壓一遍，但厚不及五公分者，可毋須滾壓。水泥和沙之墊層，適用於整齊石塊路面者，於此式路面則罕用之。

鎖面——鋪砌路面時，常須加添墊襯材料，以填塞石塊間之空隙。每石塊務使與相鄰各石緊相接合，橫接縫自左至右成一直線，須與路面中線成垂直，彈石之形式多參差不齊，而鋪者須具有相當技巧，方能鋪砌如式。石塊頭堆於鋪工之旁，其具有經驗之鋪工，即能隨選隨鋪。且能將洽當之平面鋪於上面，同時使底面亦有相當之承重力。鋪工所用之唯一工具，一端爲椎，一端爲小木夯。隨鋪隨夯，以使路面平整。每工每日平均可鋪路面二十平方公尺。若用半整齊石塊，則鋪砌愈簡捷。

檢察——當路面進行鋪砌時，須用一夯追隨於後，檢察其鋪工之優劣，每石塊均須以夯驗視其承重力如何；倘塊石質地不固，或鋪砌不合規定，或經夯打即行下陷，或接縫不緊，易致動搖，均須重新改鋪，至路面平整穩固而後已。

完成——新鋪路面經檢察後，即在路面撒鋪填縫料一層，通常即以墊層所用之材料充之。用竹帚掃入縫中，間亦有用鋼鈑插塞者。石縫填塞後，乃用三十公斤之木夯，普遍夯打一次。夯打時須自路面兩旁，漸向中央推移，夯打後或再施以輕量之滾壓，然後用樣板及邊板比驗，作最後一次之檢查，以覘有無前此未經發見之缺點。

造價——彈石路之造價，每平方公尺約二元二角，半整齊石塊路，每平公約二元八角。此造價係根據一九三三年上海市價估計之。

保養——彈石與半整齊石塊路面之保養費，均甚低廉，有時僅須將破碎之石塊，隨時抽換，即可修整如式。若在通行車輛甚爲繁複而路基又不堅固之處，彈石路或每隔數年即須翻修一次，但舊路面原有材料之價值，剩餘尚多。

結論

（一）彈石路及半整齊石塊路面，苟建造得法，實爲一種低廉耐用四時通行之路面，交通不繁之地大可採用。半整齊石塊路面，造

價稍高，但效用亦較佳。

（二） 以上兩種路面之下，能加築碎石或碎磚路基一層，至為適宜。若排水完善，卽在多雨之區，於普通土壤路床之上，建築上兩式路面亦無不可。

（三） 路基厚度，如與路床土壤及排水情形相調合，則十公分至十二公分之面層，及五公分至八公分之墊層，似已足用。石塊過大，工作較難，墊層過厚，其效用亦不見增益。

（二） 泥結碎石路

泥結碎石路，因其造價低廉，在國內公路路面中，乃佔一重要之地位。其保養殊簡易，效用亦良好，既不若卵石路易生槽床凹凸之狀；亦不如水結碎石路鬆解破壞之速。

設計與築法

築法——此種路面，因築法簡單，故能儕於低價路面之列。通用之築路方法共有二種：（一）乾法，（二）灌漿法。各地採用方法不同，湖南多用乾法，而江蘇則多用灌漿法。

設計——泥結碎石路，有築路基者，亦有不築路基者。路面通常分三層鋪於路基之上——底層，中層，及面層。各地之標準設計及造價見下表：

樣	式	壓實厚度（以公分計） 路基	底	中	面	每平方公尺之造價
乾法	湖南	——	7	5	2	$0.36—0.47
乾法	上海	20公分碎磚 25公分碎石	10	10	1	——
灌漿法	上海	20公分碎磚 25公分碎石	8	7	1	$2.45—2.90
灌漿法	江蘇	15公分大石塊	8	7	1	——
灌漿法	南京	——	12*	7	1	$1.18—1.43

底層泥結碎石路

乾法——乾法係用黃泥作結合料，其築法異常簡單。路床與路基，概依水結碎石路之路床路基造法築成，然後將路面底層鋪於路基之上，（如無路基即鋪於路床上）達於規定厚度。其上加撒選定之優質黏土，至規定份量，即以齒耙拌和，使成均勻之混合物。若交通不繁，可暫擱置若干日，俟天雨時，方以五噸重之路輾壓實之。苟急於完工者，則可澆水輾壓之。

中層及面層所用之細混料，常預將黏土滲入。滲加時並和以水，俾成濕狀。中層鋪於底層之上，其拌和法與輾壓，皆與底層同。其上再鋪面層，任車輛來往輾壓，以使堅實，或用三噸半之輕路輾壓之亦可。

上海所築之路，每用大石塊，或碎磚爲路基。湖南則有二千公里之公路並無路基，而通車成績尙佳。所用之粘土量，據湖南之報告，底中兩層，均用百分之二十至二十五，面層用百分之十。粘土須搗碎成粉，顆粒大小，須在三公厘以下。

灌漿法——泥結碎石路之灌漿法，與灌漿青碎石路之造法，完全相同，僅所灌之漿爲泥漿耳。

泥漿須用質地優良之粘土製成，其稠度愈厚愈佳，但以不妨礙其自由注入石層爲度。灌漿共有二次：一次灌於底層，一次灌於中層。每次灌漿，須至路層飽和而止。且應輾壓一遍。上層灌漿畢，即隨輾隨撒細混料，以填塞空隙。最後於已成路面上，加鋪石屑一層，即可通車。惟亦有規定於通車之前一日，尙須澆水輾壓一次者。

材料

所用碎石爲石灰石，砂石，石英石等。底層碎石，以徑大三公分至六公分級配合宜者爲佳。全國經濟委員會之試驗路，曾用十二公分厚之底層，但無路基，混料徑大至八公分者，經許可滲用。其間中層，則用二公分至四公分級配合宜之混料。塡縫料則用半公分至二公分之小石子，石屑粗細，不得大於六公厘之篩層。

湖南各地遍產砂及卵石，故多用之以代碎石，以是底層中所用粘土成份較多，自屬必需。

所用粘土通常爲黃土或紅土，因其產地甚廣，故國內所築泥結碎石路獨多。關於粘土之性質，無一定之標準，只須不含雜質而

已。

保養

泥結碎石路較優於水結碎石路者，在其效用期間較久，平時保養較易也。粘土之效用，除作結合料外，尚可充混料之裹護物，足以防止路面之迅趨鬆解。粘土之固結力，與混料之互相鑲嵌，對於高速率車輪所生之剪力，頗能協力抗負。但任何路面，吾人均不能奢望其强力有過於其中最弱成份之能力以外。故路面之粘土，因風雨之侵蝕，車輛之輾擦，日漸耗失，不數月足可使路面破敗損壞，不堪收拾矣。是以路面自築造完成後，即當常川保養；而保養之法甚簡，不外下列種種：

（a）路面加料　須常以濕土砂及石屑撒鋪路面。每逢雨後，且須巡視一週，加添路面之結合料，以保護路身。

（b）修補　路面呈破壞現狀時，須立即用乾法或灌漿法修補之。舊有之石子已成圓形者，應另易以多稜之新石子。修補時所及深度，常在三公分至五公分左右。更宜注意新鋪之處，須與舊路面結成一體。

（c）排水　泥結碎石路，必賴排水宣暢。溝渠中之亂草，宜常拔除；路肩下之暗溝，宜時加疏通，其路冤須有一與二〇之比。

造價

泥結碎石路之造價，因設計不一，各地之人工材料單價不等，每平方公尺至低約三角六分，至高約二元九角。各地各式之造價若干，已詳見前表。

養路費每公里約年需一五〇元至三〇〇元不等。

結論

（一）泥結碎石路乃低價路面之一種，若車運不甚繁重，極爲適用。因其無卵石路之易現槽形損壞，及水結碎石路之迅致破敗等弊。

（二）泥結碎石路，若常川保養得宜，可耐用至數年之久。設交通日繁，再加澆瀝青面層，其效用當更佳妙。

報告四　關於城鄉公路及交叉處所用行車安全設備方法之概述

引言

近年來中國公路之里程日增，未已，汽車數量亦逐漸增加，故運輸安全之提倡，有刻不容緩之勢。自一九三二年省市間聯絡公路通車後，欲求汽車肇禍事件之減少，公路安全保障愈形重要。近來蘇浙皖三省及南京上海兩市，對於安全之注意與合作，頗有一述之價值。各省自興築公路以來，對於公路運輸之安全，已有相當之設備，不過省市間之互相合作，以促進交通之愈趨安全，則爲國內近來之新發展。五省市所議定之統一辦法，吾人渴望其能早日推及其他行省，漸及全國。是以本報告中將五省市所進行之種種事宜，加以縷述，非不當也。

（一）管理運輸安全之法規及規則

管理運輸安全之規則，早已施行於各省市；惟因其立法之機關不一，故結果不能一統。自一九三二年蘇浙皖三省聯絡公路完成後，駕駛人及管理機關深覺不便，乃於是年秋成立蘇浙皖京滬五省市交通委員會，以改善各省市間之聯運事宜，及統一各種規則。五省市各派專家一人出席，每二月舉行會議一次，因所派代表，大都係各省市管理汽車運輸之直接負責人員，故會中議決案之執行，頗能收迅速方便之效。

委員會認定運輸安全之改進，爲其最要職務之一，對此頗多樹建，現已擬定各種規則，並已通過，例如道路運輸規則，汽車取締及征稅規則，統一道路標誌規則，及發給駕駛人執照規則等等，關於運輸安全之推進情形，將於下條述之。

（二）道路標誌

以前各省各自採用其所設計之道路標誌，不相互謀，故駛行於聯絡公路時，駕駛者深感不便。欲求互通汽車之利便，改進運輸之安全，統一道路標誌，實爲要圖。是以五省市交通委員會於第一次會議中，即將萬國道路標誌略加修改，決議採用。自後各省計劃道路標誌時，皆以此爲準繩矣。委員會爲求乘車人之便利計，亦曾將各省聯絡公路上所設置之里程牌，指示標誌及路綫，橋樑涵洞等之編號牌，予以一統。

（三）改進城市鄉間及平交道之運輸安全所採取之方法

五省市對於運輸之安全，已試用各種方法，大別之：

（a）運輸設備

（b）取締辦法

（c）救急設備

（d）教育工作

（a）運輸設備

有若干道路，對於各種運輸設備，均已設置，例如標準道路標誌，與交通號誌之安設，交通警察及機車巡邏隊之任用，危險地帶護欄之堅立等等。他如平交道或坡度之劃分（Separation of Grades），短曲線之廢除，狹橋之放寬等等，均當於交通情形已達其需用之時期，次第實行。

（b）取締辦法

取締不良汽車行駛路上，現已實行。同時所有汽車均須於規定期間內，經由各主管機關詳細檢查。五省市交通委員會現亦預備擬草汽車穩妥保險強制法規，並製定公共汽車之設計標準。

（c）救急設備

肇事後之緊急救護，現已倣用泰西各國之方法，如設置救護車，與醫院合作，在長途汽車上攜帶救急藥箱，分送『救急法』小書等等，皆交通委員會所已行諸事實者也。

（d）教育工作

關於教育事宜，已致力於下列三項：（一）民衆之教育，如張貼行路安全圖，發行各種指南，及利用報紙，無線電，公開演講，影戲幻燈，以推廣安全運動。（二）駕駛人之訓練，現準備設立訓練學校，印行駕駛人須知各書。（三）交通警察之訓練，將交通規則及法規，向之講解。蓋弭除用路者發生危險之各種原因，實有不少教育之方法，可以提倡試用也。

關於改進城市鄉間及平交道之運輸安全所採用之各種方法，將於以下各段中詳述之。

（a）城市中

改進城市中交通之安全，應注意於徒步交通與車輛交通之分隔，及車輛交通相互間之彼此分隔。蓋分隔後，相遇之機會少，相遇之機會少，則肇禍之次數，亦隨之減少矣。欲解決此問題，第一步即須將窄狹之街道放寬，然後人行道方可擴大。中國各市政機關，大都均已着手規劃城市設計，及訂立市屋移讓規則，市街之放寬亦已於各大城市中逐漸實行。

凡市街之尚未放寬者，則採取下列各種方法：

（1）規定此種市街，僅能用作單向路。

（2）禁止某種車輛於一定時間內，在有過期性擁擠狀況之市街中通行。

因汽車肇禍最易發生於交叉處，故採用下列種種方法以預防之：

（1）交通警察，指揮車輛。

（2）標準交通號誌。

（3）安全島及安全區之劃定。

（4）建方圍或交通圈。

最困難之問題，似爲管理行人之橫過市街中部，因汽車駛近路叉時，其行必緩；但在中途其行也遠，並無掣車之準備，故時有發生危險之可能。

國內各城市之市街，大都狹陋不堪，故車行速度，限定甚低，汽車肇禍之次數，得以減少，但汽車因高速度而取得之效率，則被損棄殆盡矣。

（b）鄉間

在交通不繁之鄉間，苟車行速度甚大時，下列各法，足爲運輸安全之保障：

（1）在路叉處將坡度減小至最低限度。

（2）就已成各路改良路線。

（3）在危險地建立護欄。

（4）設立標準道路標誌。

（5）取締破舊車輛。

（6）置備救護車及救急設備。

國內之舊式車輛，各地尙多，其製造之粗笨，及行動之遲緩，不僅對於道路之修養增大費用，且對於高速度之汽車運輸，亦爲一種阻礙。爲免除此種弊害計，在汽車道之側，另鋪石子車道，專供舊式車輛行駛。

（c）平交道

求平交道運輸安全之改進，曾採用下列各種方法：

（1）設立危險標誌。

（2）設立鐵路柵門，由看守人啓閉。

（3）用交通警察指揮交通。

他如需費較大之坡度劃分法。建築天橋或隧道等，當運輸量已增至其必需之程度時，亦可採用。若交通在人烟疏稀之處，宜用自動號誌。交通委員會曾計劃一種自動光號，在鐵路與公路交叉處，可供採用。

結論

（一）交通規則須力行統一。

（二）駕駛人及民衆與交通警察，對於運輸之安全，均應有相當之訓練。

（三）公路上應有各種安全設置，例如道路標誌，護欄，交通警察等。

（四）除其他原則外，交通之安全，亦爲計劃公路時所應注意之一點。

（五）汽車務須與各種安全上之規章相符，破舊或危險之車輛應予取締。

（六）緊急處置，例如救急設備等，應予以同等之重視。

（七）行人及乘客與駕駛人，均宜令其各自小心。

報告六　研究關於現行法規限制公路車輛載重及其大小之利弊

（a）提出關於下列各項現行規則

（一）關於限制車輛之載重者（實車或空車）

（二）關於限制車輛及其所載貨物之闊度及高度者

（三）關於限制車輛及其所載貨物之長度者

（b）詳細批評此項規則所發生之利弊

（c）討論此項規則在國際間是否有劃一之必要

倘屬需要宜以何項原則爲劃一之標準

中國之汽車大多集中於各大城市，與各大城市相互聯絡之公路上。在五省市交通委員會未成立之前，管理汽車之規則，各自爲政，不相爲謀。自交通委員會成立以後，曾將現行規則，細加研究，並予修訂，以期劃一。該會之組織，日漸擴大，苟里程愈增，車輛愈多，最近之將來，不難推及全國。關於公共汽車及雙門轎車之統一規則，現已實行，惟關於其他汽車之規則，尚待擬訂。下列各條，係關於車輛載重，闊度，及長度之節略。

（一）（a）城市中有高級路面之道路，據市政機關之規定，最大載重，可至一二，〇〇〇公斤；惟公路上不得超過七，五〇〇公

斤。而空底盤之重量並無限制，但任何車輛，均不能載重超過工廠中所規定之數目。

（b）各種車輛，除公共汽車及雙門轎車之外，其最大外闊爲二・五公尺。單層公共汽車及轎車爲二・四公尺。前後輪轍，務須相同，其寬不得少於最大外闊之百分之七十。車輛之總高爲三・七五公尺，公共汽車，雙門轎車，及貨車均同。雙層公共汽車，國內用者尙少。

（c）商用車輛，不附拖車時，連車身及裝貨全長不得過十公尺。如附拖車時，連車身及裝貨，全長不得過十八公尺。單層公共汽車及轎車，則限於九公尺。

（二）此種規則所制定之最大限度，其目的在求交通之安全，但不無有限制重載貨車行駛於公路上之嫌。

（三）就整個汽車業而論，各國劃一此種規則，實屬必要。倘各關係國，能根據公平合用及經濟之原理，爲之製訂，我國未有不樂從也。

結論

汽車載重闊度，及長度各項規則，如能劃一，第一，對於管理機關處理目前日繁之交通問題，實多利賴。第二，對於汽車商人亦爲良好之南針，因可以知所改良，以應吾人之需要。第三，由上所述，如一國之汽車規則統一後，久而久之，不難促成國際間汽車規則之劃一，則預卜將來之汽車世界，不復有今日之面目矣。

附錄一　湖南省建築泥結碎石路報告

周鳳九
歐陽鎧寰

本省修築行駛汽車之公路，僅有十年歷史，所建築之路面，係採用泥結馬克當式，每日平均行駛三噸載重汽車次數，約五十次，營業事宜，由省政府設局辦理。建築及養路經費，概由政府籌措。茲將路面寬度，材料選擇，路面建築及修養方法，費用等，逐一縷述如次。

一、路面寬度

路面寬度，以能行駛兩列汽車爲準，規定全寬爲七・三〇公尺，車行道佔四・六〇公尺，兩邊人行道，各佔一・四〇公尺，遇灣道處，另有加寬之規定，若遇岩石開鑿工程過大，則路面亦可酌量改窄，以省工費。

二、路面建築方法

甲，概論——路面建築，採用泥結馬克當式，以限於經費，厚度改薄，並省去大塊石之基礎層，據歷年實驗所得，倘建築得法，使路面時常保存弧形原狀，易於排洩，且使堅結，不透雨水，土基無滲濕積水弊害，則此式尚可應付目前交通而有餘。車行道上建築之砂石路面，分三層鋪置，共厚十四公分，兩邊人行道，則僅鋪面層細砂而已。

乙，砂石之選擇——路面底層中層，或用碎石，或用卵石，就地方情形決定。碎石以石灰石花崗石砂石等堅硬粗糙易結合者爲上品，性脆弱易風化不耐磨擦者，概屏勿用；卵石則就沿路溪港或山中採用，以少含泥質粗糙堅硬者爲佳；面層細砂，以顆粒粗糙少含泥質者爲佳。

丙，砂石之大小——底層石子，以徑大七公分爲度，因底層厚度僅八公分，若石子過大，則不能鋪壓平整；中層厚度爲五公分，石子徑大以二公分爲度；面層細砂，大小以〇・二至〇・五公分之顆粒爲宜。底中兩層石子，大小宜均勻，不宜參差，其空隙（Voids）以

大爲佳，否則減小結合材料之位置，不能藝壓堅實。

丁，砂石之數量——底層石子，規定每平方公尺路面，鋪〇・九立方公尺，中層鋪〇・〇六五立方公尺，面層鋪〇・〇二立方公尺，并人行道所鋪之砂在內。

戊，結合材料——結合材料，採用黃色粘土（Red Clay），無草根等雜質者，其成分隨石子之性質而異，底層粗砂，用卵石者，爲百分之三十至三十五，用碎石者，爲百分之二十至二十五；中層分砂，用卵石或碎石者，均百分之二十至二十五；面層細砂，爲百分之十。粘土使用時，須搗碎成粉，顆粒大小，約三公厘。

己，路面弧度——路面弧度規定，爲拋物線形，中部高出路邊十九公分，即平均斜度爲二十分之一，蓋過平則不易洩水，過凸則於行車有礙，此歷年實驗所得之有效方法也。

庚，工事實施——鋪砂施工前，應將土基切實驗看，然後挖做路床，務令平水弧狀合度，乃將三層砂石，分層鋪置。各層砂石與粘土拌和後，必須稍經時日，（能得天雨濕透最好）方施藝壓。底層粘土，可於石子鋪開後參放，用鐵齒梳耙推動，送入石子空隙之內；中層及面層粘土施放方法，應先與砂石參合濕水，拌勻後，再行展開。

辛，路藝——路藝係水泥混凝土製造，約重三噸半至五噸，用人工拖引。大藝五噸者，用以藝壓底層及中層，長一・二五公尺，對徑一・八〇公尺；小藝用以藝壓面層者，長一・二五公尺，對徑一・一〇公尺。各層砂石，應施藝壓之次數，底層爲五次，中層三次，面層二次，每次必於天雨或灑水後行之。

壬，排水——此種路面土基，最忌積水滲濕，故排水之方法，極爲重要，除切土坑內做邊溝之外，於鋪砂前挖做路床時，兩邊人行道下，每隔二十公尺，應做深寬約二十五公分之暗溝，用石子填滿，宣洩底層積水。若切土路基上發現伏泉，則應做特殊工事以排去之。

三、路面建築費用

路面建築費用，係由砂石採取，運輸，及鋪置三項價值而成。用卵石者，平均每平方公尺洋三角六分；用碎石者，平均每平方公尺

洋四角七分。

四、路面修養方法

甲，路面損壞原因——此種薄層路面，損壞原因頗多：夏季暴風急雨，使面砂飛散；冬季冰雪，使路面砂石受濕縮影響而鬆解；車輪衝擊，使路面砂石鬆動散去，致成槽坑；車輪摩擦，使砂石壓成碎粉，以致散失；邊溝壅塞，使路面積水，滲濕路基；草皮未除，使沖積物堆集；路面不平，且易積水；土基不實，路面受壓，發生沈塌，此其顯著者也。

乙，修養方法　1. 加面砂——面砂被暴風雨，車輪衝擊，及冰凍影響，以致散失，使中層砂石暴露，車行震動，路面易受損害，故每年應於四月，八月，十二月三時期，全路各加鋪面砂一次。　2. 補槽坑——凡槽坑發現，須立時修補，免致擴大，小者只加分砂和泥填塞，用抬槌築緊，大者須將底層粗砂及中層分砂，重新鋪置，用小轆壓緊，稍經時日，加蓋面砂。　3. 粘土成分——路面補修面砂分砂內參和粘土成分，於天時氣候大有分別，夏秋季宜重，爲百分之三十五至四十，春冬季宜輕，爲百分之二十至二十五。　4. 疏濬邊溝——雨水冰雪，均易使切土坑流坡上泥砂崩下，壅塞水溝，應隨時疏濬，以防積水滲入路面。　5. 挖除草皮——春夏季路面人行道，草皮易生，弊害滋多，應於每年四月，七月挖除一次，挖時，以雨後爲宜。

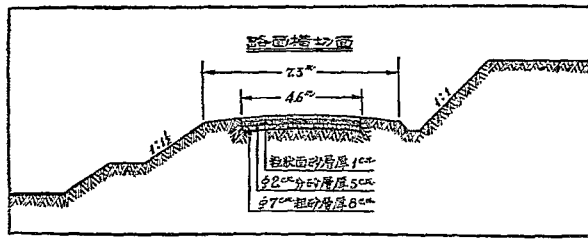
五、路面修養費用

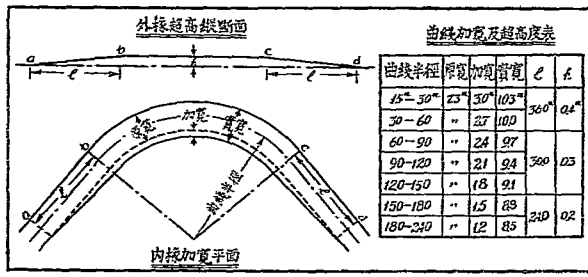
養路工人，爲棚工制，長期雇用。工餉按月發給，分駐沿路工作，每一公里，設棚工一人。砂石材料預備，用包工制，覓人承辦，每年每平方公尺路面平均需修養工料費洋五分，卽每公里，約需洋二百三十元，其中工資費，各佔百分之五十。

結論

此種路面，建築費雖省，但修養費頗鉅，每年支出，幾佔其建築費全額八分之一。現在情形，每日車輛次數，計重載車平均約五十次，車重約五噸，路面尙可維持平整，倘將來車輛次數加多，或車重加大，則此種路面，必須加鋪塊石基礎層，增其强度，建築費須增加五分之二，但修養費或可減少。據歷年實驗所得，碎石路面實優於卵石路面，其修養費可省五分之二。

附路面橫切面及曲線加寬並超高度表各一





曲線加寬及超高度表

曲線半徑	原寬	加寬	實寬	ℓ	f.
15—30m	23m	30m	103m	360m	04m
30—60	〃	27	100		
60—90	〃	24	97		
90—120	〃	21	94	360	03
120—150	〃	18	91		
150—180	〃	15	89	240	02
180—240	〃	12	85		

附錄二　漢口市水泥築路之成績

蔡鈺

築路之經過

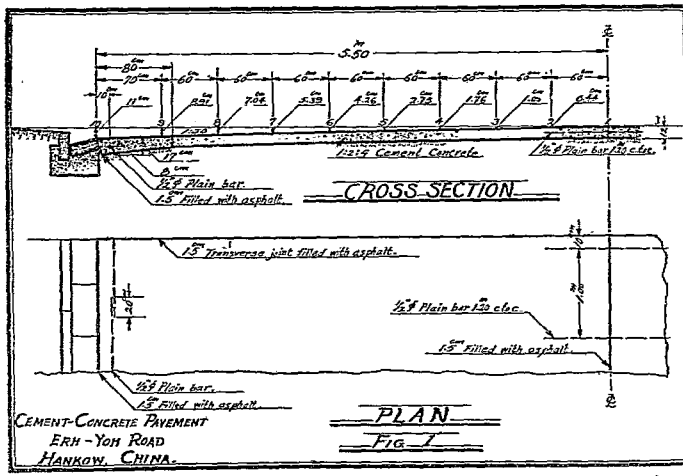
漢口市在民國十八年(1929)以前，市中心區(Civic Center)內道路悉爲碎石路。(Water-Bound Macadam)至十八年，市政府成立以後，所有新闢及改良之道路，悉爲柏油路。四年之內，十九年(1930)起至二十二年(1933)止，進行甚速，計由二公里增至二十四公里，柏油路至現在已佔市中心區道路百分之四十。二十二年(1933)爲水災後復興時期，市長吳國楨銳意革新，以碎石路既不足以應需要，而柏油路又每年漏扈甚多，擬議採用國產水泥，建造水泥三和土路，(Cement-Concrete Road)爲漢口倡一新的建設。復經工程人員從經濟及技術兩方面詳細考慮，認爲可行，先後告成者有二曜路，(Erh-Yoh Road)長三九一公尺，次爲中山路(Chung-Shan Road)中段長爲九五七公尺。此外又在中山路試造水泥碎石路(Cement-Bound Macadam)一段，此爲漢口市水泥築路之始。

甲　二曜路及中山路水泥三和土路

設計大要　二曜路原爲堅固之舊碎石路，在含有住宅區性質之地段內，車輛不多，最適宜修造水泥路。形式採用厚邊式(Thickened-edge type)以路基穩固，厚度僅規定爲17—12—17(俱以公分計)路冠(Crown)傾斜度，爲一比五十。路面灣度爲拋物線。路面接縫(Transverse joint)每距十公尺一條，闊一·五公分，灌柏油。縱向接縫(Longitudinal joint)沿路邊及路拱中心線共三條，俱嵌油毛氈夾柏油，水泥三和土成份爲一·二·四。(參看第一圖)

中山路寬八公尺，交通甚繁，路基爲二十餘年舊碎石路基，堅固結實。水泥三和土路面橫斷面中部稍厚，(參看第二圖)路冠傾斜一比五十，接縫每距七公尺一條，灌柏油。水泥三和土成份亦爲一·二·四。

材料　二曜路所用水泥，爲中國江蘇龍潭中國水泥股份有限公司所出之泰山牌水泥。(The "Taishan" Brand Portland Ce-



ment Manufactured By The China Portland Cement Co., Ltd., Lungtan, Kiangsu, China）該項水泥色澤，凝結時期，勁力壓力等性質，俱遠勝於本埠通用之湖北大冶所出之寶塔牌水泥。石子爲本省出產之石灰石（Limestone）大小規定甚嚴，在六·三公分與二公分間之碎石居兩成，二公分以下〇·八公分以上石子居一成。先用篩分別篩出，洗去泥土，再按上列成份拌和。

粗砂爲湖北漳洲出產之粗砂，選擇頗精細，其規定如左：

經過每英寸十眼篩留於二十眼篩者	10%
經過二十眼篩留於五十眼篩者	40%
經過五十眼篩留於一百眼篩者	45%
經過一百眼篩留於二百眼篩者	5%

手工　製造多量水泥三和土，自以運用機械爲適宜。但本市現尚缺乏此種機械，故不得不仰賴人工。殊知現在工人失業者頗衆，固不得不因建設以籌救濟。查現在工資低廉，工費僅佔工程費總額百分之七左右，（見後第六表）恐即用機械，亦無如此之廉，此在中國社會固不必定須採用機械也。再查中山路極爲狹窄，如用機械製三和土，則三和土薄送，恆在五十公尺以外，反不如人工之可以就近調和，隨調隨用，不限地點之較爲便利，此在工程方面，亦似不必必須機械機械也。

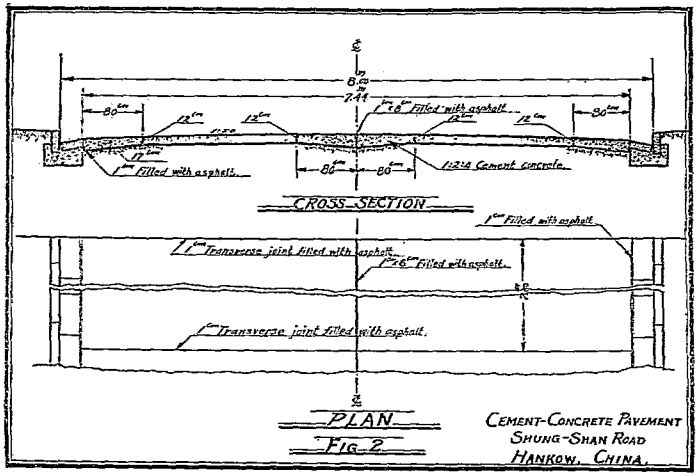


FIG. 2.

本府建造道路工人，原係本府常雇工人，頗具修路經驗。實地考察，每一〇四人工作一日，可造成路面二六〇平方公尺，其人數分配如左表：

表一

建築人路土和三泥水數工

工作種類	人數
挖路基雜工	20
挑砂	8
挑石	12
運水泥	8
上石	4
送水	4
洗石	16
和三和土	32
共計	104

現在常雇工人，每日工資（十小時工作）平均約四角六分。一〇四人共四七・八四元，由此計算，每平方公尺面積工費只〇・一八四元，其值不可爲不廉。

三和土之調製 三和土混合材料，俱用量斗量取。量斗爲一內高闊深各三十公分之木盒。先將水泥及粗砂，按照規定成份，倒置鐵板上乾調。每一單位地點，約用六人調和，俟全部顏色均勻，再加石子拌攪，隨注入清潔自來水。水量每一桶水泥約用水二十四加侖之譜。但工人習慣，多

喜用過量之水，以便工作。此種辦法，易使各部份材料脫離，而損壞路面强度。在中山路施工工作之時，曾有一處因三和土太濕，至石子悉沉下面，上面惟稀薄之水泥漿，此處路面，必不能耐久。以後施工人員對於使用水量，除照規定水量量取外，並以路面不呈積水爲標準。

路基之整理　二曬路及中山路俱爲舊碎石路基。在鋪築三和土路面之前，先將老路挖起約十公分，並修成與設計路面相同之灣曲形式，用水洒濕之後，再倒築三和土。兩傍人字溝邊石爲求整齊及使三和土路面澎漲一致起見，同時加以改造。

路面之修理　修整路面程序凡三：(一)造形，(二)碾壓，(三)熨平

施行造形工作，先按規定灣度，用洋松製成模板一塊，二曬路分兩邊建造，模板長度，約爲路寬之一半稍長。中山路係按路寬整個倒築，模板長度，約與路寬相等。每一處三和土鋪滿，路高於規定厚度，隨將由度板兩頭安放邊石及路中模板（指二曬路分邊建造說法）上，向前推送。工人初不熟習此種技藝，但數日之後，便覺熟能生巧。惟中山路係整個建造，全寬七·四四公尺，施用此法，稍形困難，但仍按照規定灣度，製造模板，安放路基之上，再按模板形式，高修整路面。

碾壓，在三和土路施行中，爲比較困難之一種工事。工程家對於水泥三和土路多主張不加碾壓者。但三和土路，經碾壓後比較優良，則可斷言。本府爲碾壓三和土路，特製直徑三十公分，長約一·八公尺，重約二〇〇公斤（kg）小鋼碾一件。施用時，與路線成直角方向，用繩牽繫，來回碾壓，凡經碾壓路面，俱固結光平。惟鋼碾雖重只二〇〇公斤，施行時，頗覺不便，現擬再加以改良，將鋼碾長度減至六十公分，直徑更減小至二十公分，庶輕便易舉，而又能收固結之效。

施行熨平工作（Finishing）係用特製之短柄熨斗（Hand Float），在接縫處，用橋式熨斗（Bridge），每塊三和土路面倒成之前，（或碾壓後）於路面搭板，施行該項熨平工作。熨斗俱用木製，底面毛而不光，藉以減少路溜滑程度。

濕治（Curing）　二曬路開工在本年九月，至十一月完工。中山路開工在十一月，至十二月底完工。在此期內，天氣時陰時晴，暖而不寒，爲建造三和土路最好天氣，蓋能幫助濕治工作不少也。兩路施行濕治方法，俱係於每塊三和土路面築成後，用濕蔴布蓋上，時時

噴水，約兩星期，開放交通，此種辦法，在交通比較稀少之二曜路，尙無如何妨礙，但在車輛繁盛之中山路，造斷交通如此之久，殊不甚便；亦係最難辦到之事，因每每不能依至規定濕治期限完畢，卽行開放交通，致將來有易於裂拆之可慮，故修築此種路面，須以忍耐出之也。

二曜路橫接縫（Transverse joint）每條相距十公尺，中山路每條相距七公尺，每日收工總以完成整塊爲限，不多留接縫。

完工後之考查　水泥三和土路，在本市本係倡舉，故築成後，一般市民及外人均有良好批評。其感覺之優點有四：（一）工程方面優點另於後面結論述之）（一）路冠較平，行人車輛俱較舒適。（二）各種車輛均因阻礙力小，易於行走。（三）路面極清潔，可以收雨水自然冲洗之妙。（四）顏色悅目。

按水泥三和土路，比柏油路路呈灰白色，但色澤良否，與所用水泥種類，亦有關係。二曜路所用水泥係泰山牌，中山路係用寶塔牌水泥。泰山牌水泥稍帶青色，做成路面，色白而明。寶塔牌水泥現灰色，做成路面，色灰而暗，殊不若二曜路之悅目。但該二路自開放交通迄今，路面均無破壞及裂拆之處。將來修養路面，將以柏油爲主要材料。

經費　本工程材料數量，經精密估計，其實用與預算額相較，極爲相近。工人原係本府常雇工人，預算內向不列工資，但爲便於參考起見，仍按實支工價折合，俾明工程價額之眞相。監造費向包括在工具雜費項下。查二曜路面積共四三〇一平方公尺，共用水泥一一六〇桶，粗砂二五八立方公尺，石子五一六立方公尺。中山路共用水泥二〇三九桶，粗砂四五三立方公尺，石子九〇七立方公尺。茲分別列表說明。第二表爲二曜路及中山路每一〇〇平方公尺面積材料比較表。第三表及第四表爲二曜路及中山路估計單。由第三及第四表，得知工費佔少數，因就材料工費雜費各百分率復列一表，（第五表）俾明材料費及工費之比較焉。

由下第三及第四表觀察，兩處水泥三和土路面每平方公尺單價如左：

二曜路	二・七六元
中山路	二・九〇元

表　二

水泥三和土路每100m³材料比較表

材料名稱	二 曜 路	中 山 路
水　泥	27 桶	28.4 桶
粗　砂	6 m³	6.3 m³
碎　石	12 m³	12.6 m³

表　三

二 曜 路 估 價 單

種　別	稱呼	數　量	單　價	銀　額
水　泥	桶	1160	7.00	$8120.00
粗　砂	m³	258	2.30	593.40
石　子	m³	516	2.50	1290.00
工　費	m²	4301	0.184	791.38
				10794.78
工具雜費	10%			1079.48
共　計				11874.26

表　四

中 山 路 估 價 單

種　別	稱呼	數　量	單　價	銀　額
水　泥	桶	2039	7.00	14273.00
粗　砂	m³	453	2.30	1041.90
碎　石	m³	907	2.50	2267.50
工　費	m²	7177.5	0.184	1320.66
				18903.06
工具雜費	10%			1890.31
共　計				20793.37

表　五

水泥三和土路面材料工費雜費百分率比較

項　目	二 曜 路	中 山 路
水　泥	68.40%	68.70%
粗　砂	5.00%	5.02%
碎　石	10.87%	10.90%
材料合計	84.27%	84.62%
人　工	6.67%	6.35%
工具雜費	9.05%	9.03%
總　共	100.00%	100.00%

此項建造經費，雖比柏油路略昂貴，但柏油路每至夏天需用石屑（Stone Chips）維持路面之故，每年所需維持費，頗屬不少。至水泥三和土路，則無須需此，故年代愈久遠，水泥三和土路愈經濟。

新建二曜路水泥水路三和土路

乙　水泥碎石路面 (Cement-Bound Macadam)

修路經過　中山路爲本市重要幹路，路線甚長，原擬翻修柏油路面；嗣以柏油一項利權外溢過多，始議採用國產水泥改造三和土路。但水泥三和土路造價頗大，求一介乎三和土路與碎石路間經濟而又耐久適用之道路，厥爲水泥碎石路面。查水泥碎石路材料，雖以水泥爲重要材料，但所用數量較少，仍以大石子爲主，故甚經濟。至工事方面以及所用工具之簡單，幾在碎石路之上。故於中山水泥三和土路未開工以前，先行修築水泥碎石路一段，以資試用；長一〇〇公尺，寬八公尺，面積八〇〇平方公尺。

建造法　建造水泥碎石路面之先決條件，在能得一十分堅固之路基。中山路係多年舊碎石路，堪供修造水泥碎石路之用。翻造之時，(一)只將舊路面略事翻挖檢平，鋪五公分至十公分大小片石一層，用十噸重壓路機洒水充分碾壓結實(厚須十公分)，然後將調和好之一：一水泥漿均勻鋪上，耙平。先用小鋼磙洒水碾壓，隨用十噸重壓路機碾壓，至水泥漿全部灌入縫隙爲止。路面築成之後，亦如建造水泥三和土路辦法，施行濕治(Curing)工作二星期後開放交通。該路自完成後迄今尚無裂罅情事。其估計及使用材料及人工分配如左兩表：

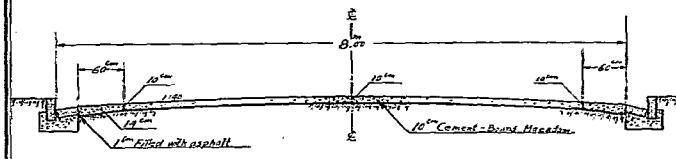
表 七

水泥碎石路人工表

工作種類	人數
挖路基築雜工	8
挑砂	4
挑水	2
碾壓	3
灌漿	10
掃漿	1
洗石	12
共計	40
每日能完 130 m²人數	

表 六

種別	每呼	數量	單價	銀額
片石	m³	107.00	2.40	256 80
水泥	桶	133.00	7.00	931.00
粗砂	m³	15.20	2.30	34 96
				1222.76
人工	工	246.00	.46	113 16
				1335.92
雜費	10%			133.59
共計				1469.51



CROSS SECTION

FIG. 2

CEMENT-BOUND MACADAM CONSTRUCTION

CHUNG-SHAN ROAD

HANKOW, CHINA.

由此推算，水泥碎石路面每平方公尺需洋一・八四元。比普通碎石路造價每平方公尺約高九角，而其使用年限（查市區內碎石路使用年限難達一年）則決不止兩倍，自屬一種經濟建設。惟本地工程家對於此種路面尚在懷疑，故暫時只造一小段，以資試驗，將來經長時間之試驗後，或有採用之趨勢，亦屬意中事也。

丙 結論

凡稱爲經濟之道路，不必定爲造價低廉之道路。碎石路造價，可爲低廉矣，但不數月即壞。每年所需之養路及翻修費，多至三年，即可超過水泥三和土路或柏油路之價值；而在使用期間，其他收益上之損失，如汽油之耗費，土地房屋價值之低落，商店營業不發達，稅收之不旺等等，尚不可勝計。故在城市中，尤以在熱鬧市區中，最經濟之道路，莫過於柏油路或水泥三和土路。再以柏油路與水泥三和土路比，柏油一項，來自國外，徵論其價值是否低廉，而每年漏巵之巨，頗足以損國家元氣，而使本國實業頻於不發展地位，自不得謂之一種經濟建設。蓋所謂經濟建設者，須綜合各種有關係問題，而加以討論也。

查我國現在水泥製造業，甚形發達。工程界若能盡力推廣之，則必能謀進一步之發展及改良，而工程上之設計，愈益經濟。

茲更從工程方面論之，每一種道路，各具一種特殊之點。於經濟問題之外，須研究其是否適合當地情形。

查本市夏季熱度常達一百度以上，柏油路路面既易溶解，反射尤烈，不但每年所需撒佈石屑維持費爲數頗巨，而人力車（本市人力車輛頗多）行此極熱之路上，步履極爲艱難，此爲本市改造水泥三和土路原因之一。又本市地位狹小，而人口繁庶，街市清潔，最難維持。碎石路固無論矣，即柏油路亦有藏垢納污之可能，惟水泥三和土路較易維持清潔，且極美觀舒適，此爲採用水泥三和土路原因之二。

又查建造柏油路必在夏季及晴天，冬季及雨中殊不適宜。工程進行上，因此頗受一種限制，時覺不便。至水泥三和土路，除嚴冬凝凍時期不能進行外，其餘時期，無時不可工作。此爲採用水泥三和土路又一原因。

綜上所論各節，水泥三和土路，在本市已成爲最適用而經濟之道路，雖其優劣之點，尚須經長時期試驗之論斷，但不數年，在本

市或將奪取柏油路之地位，則可斷言。他如水泥碎石路，在地帶偏僻地方，亦大有採用價值。現在全國各大城市及商埠，以言高等道路，無不採用柏油路，對於水泥三和土，鮮少注意，故成績寥寥。推其原因，無非因（一）建造水泥三和土路時，手續較繁，而做成後發生裂拆，不易修補，故多視爲畏途，不敢輕於嘗試；（修造柏油路，手續亦不易，但施工者，每多不肯嚴格遵照規定方法施工）（二）水泥三和土路造價有時比柏油路昂貴，不願採行；（三）修造水泥三和土路，遮斷交通較久，感覺不便。稽上三種原因，可爲水泥三和土路前途發展之一大障礙。爲改良路政及發展國產水泥實業計，深望全國市政當局及工程家，予以相當之考慮及應用。對於財政充裕之城市商埠，尤望打破造價昂非經濟之誤解，而予以相當之提倡。此外工程家對於水泥三和土路應用材料之性質及作法，亦應參照各地情形加以相當之研究，俾水泥三和土路漸成爲一種普通之建設，則施行漸易矣。

附錄三　上海市道路交叉點之交通安全方法

上海市公用局

本市對於城鄉及鐵路交叉點之增進交通安全方法，已施行者計有二種，即標誌之警告與崗警之指揮。大致視各該處環境需要而定，茲略述如次。

一、標誌之警告　此項標誌之式樣及裝置，係依照民國二十二年十一月，蘇浙皖京滬五省市交通委員會議決通過之公路交通標誌號誌設置保護規則之規定辦理；而與一九三一年三月十日日內瓦國際統一道路標誌公約之規定稍有異同，爲適合吾國地方情形起見，故將標誌邊框之顏色除醫院標誌外一律採用紅色，以標誌之形式已有類別，無再用其他複雜顏色之必要，且紅色之易以引起注目也。又如標誌上附有文字者，一律改用中文，以便國人之認識。至於警告標誌之樹立地位，規定距離其所警告之地點，至少爲一百公尺，至多爲一百五十公尺；良以近今汽車之制動裝置，日趨靈敏，其制動距離，因之日益減少，故樹立標誌之距離，亦較公約規定爲少也。

二、崗警之指揮　此項指揮，全恃崗警之手號，而崗警之指揮手號時，則視汽車司機人之手號而定；本市於此兩種手號之式樣，均有規定，庶汽車司機人與崗警間，均可互相了解，不致有誤。

除上述兩種辦法以外，最近計劃在交通繁複之處，採用非自動紅綠燈光號誌之指揮；係採用紅綠兩色制。至對於色盲者之補救，則擬將紅綠燈形再加三角及圓形之區別，以資辨別。尙在試驗研究中。將來辦有成效，擬在鄉村或荒僻處之鐵路交叉點，設置自動紅綠燈，爲增進交通安全之標誌也。

附錄四　上海市對于車輪載重及車身大小之規定

上海市公用局

上海市爲保護路面起見，對於車輛輪胎方面，曾在本市陸上交通管理規則訂定限制條文，節敘如下：「各種車輛輪胎之種類，應使路面所受之壓力如下：一、空心橡皮輪胎每平方公分不得超過七・五公斤。二、其他車輪不得超過十五公斤。」此項條文，即爲限制實心橡皮輪胎及鐵質車輪之車輛而設，因實心及鐵質車輪，載重加多，而車輪與路面接觸之地位未能加大，徒然使路面所壓力增高，易傷路面，不言而喻。故蘇浙皖京滬五省市交通委員會，對於實心輪胎之汽車行駛公路，絕對取締，蓋以新闢之公路路基，不能與城市道路相比擬也。

滬市情形，又與其他城市不同。各種車輛，亦至複雜。除載重汽車外，易傷路面之車，厥惟獨輪小車是，此項車輛之構造，又與其他車輛不同，裝載重量貨物，悉在車輪兩旁，因中間僅有車輪一具，全車壓力，均集中於此輪，輪爲木製，外面包以鐵質，其有傷路面，至爲明顯。故五省市交通委員會，對於此項車輛，有限制行駛公路之取締，本市現擬議在公路路面兩旁（或僅一面）添安石條，限獨輪小車，必須在石條上行駛，藉以減少路面之損傷。然石條安放，需費亦鉅，謂之治標則可，治本之計，猶有待於研究改進。至滬市城廂一帶，人烟稠密，純屬舊式街道，值仄異常，一時不易寬放，對於行駛獨輪小車之補救，以及種種保護路面之設施，尤非短時期內所能着手也。

本市對於車輛之構造，除特別規定者外，其車身總長，不得超過九公尺，闊度不得超過二公尺半，已在陸上交通管理規則中明定限制。

至於各種汽車載重量之限度，則以各國車廠出廠時原來限止之載重量爲準，不容超過，以避危險。蓋經售汽車之商行，往往爲競爭行銷起見，將出廠時原來限止之載重量蹙匿妄以高額載重，炫人耳目，以利銷售，購者不察，每易墮其術中。故本市對於各種汽車之載重量，隨時根據外國各該車廠原定限量，予以深切注意也。

附錄五　上海市之石塊路

上海市工務局

第一節　材料

上海市所用鋪砌石塊路之石料，全係江蘇省蘇州金山所產之花崗石。照上海市規定，得分成如下列之四種：（附表一）

（一）石塊分類表

號數	名稱	長公分	寬公分	厚公分	說明
1	彈街片	13(5″)	8(3″)	(4″-6″) 10—15	爲不等邊之菱形石片一面做平
2	方頭彈街片	至多13(5″)	8(3″)	(4″-6″) 10—15	即係上開之彈街惟兩端做方頭
3	小方石	8(3″)	8(3″)	10(4″)	方形石片一面做平四面鑿齊
4	長方石	13(5″)	13(5″)	13(5″)	長方形石塊一面做平四面鑿齊

每種石料於建築路面時，其需用之數量詳附表（四）。惟彈街片及方頭彈街之數量按所用公方計算；小方石及長方石則照塊數計算。

按石塊爲堅硬質料，欲求路面之平整，必有彈性或流動之襯墊材料爲之承托，此等材料謂之路襯。上海所用路襯有四種：即煤屑、黃砂、石屑、及石屑或黃砂與水泥之混合料是矣。各項路襯之品質及其分配於各種路面者，有如附表（二）

（二）路面路襯分配表

路襯種類	適用之路面	備註
煤屑	彈街及方頭彈街	須不含泥質及其他雜質者
黃砂	彈街,方頭彈街,小方石,長方石	須浙江省甯波產粒粗角銳不含雜質及泥沙
石屑	仝上	須浙江省杭州產或江蘇省松江產青石屑
黃砂水泥，石屑水泥	小方石及長方石	此項比例爲 1:4 水泥須爲啓新馬牌，上海象牌，或龍潭泰山牌等同等水泥

第二節　路基

用於石塊路之路基爲碎磚基或大石塊基。但有時爲節省經濟，或其交通情形不甚繁重，而土質較優者，往往即於土基上鋪築。惟小方石及長方石路均有路基。

碎磚基　磚料用純淨碎磚，有缸爿瓦片以及其他雜質者，概剔除之。於運到工作地後，即用鋤鐽拉平，其鬆方厚度須爲二十公分，迨用六噸或八噸之滾路機滾壓平實後，應爲十五公分。

大石塊基　石料用江蘇省蘇州金山產或松江產之山石。每塊至少高二十五公分，如底面之寬度小於二十五公分，或其重量不滿二十二公斤者，概剔除之。塡縫料用較小石片，但其品質應與大石塊同。鋪砌大石塊基時，大面貼靠土基，銳角向上。排砌時宜由路邊鋪向路中。所有縫隙即用小石片一一滿嵌。面層並用小石子掃縫。鋪竣後，宜用夯杵夯打，或用滾路機滾壓堅實之。

各項路面與路基之分配如附表(三)

(三)路面路基分配表

路面種類	路基情形
彈街片或方頭彈街	土基或碎砌基或大石塊基
小方石路	碎砌基
長方石路	全

第三節　鋪砌石塊路

當底基完成後，鋪砌石片或石塊以前，應先鋪黃砂或石屑等路撫一層。路撫經勻平後，其厚度以能等於石塊厚爲適；有時亦可酌減，但至少鬆方厚度應有八公分。當黃砂等材料傾卸路中時，石片等可卸於路側，俟鋪砌時，再行取運。砌路工人應站在已砌成之路面上或路側鋪砌，以免將路撫材料先行踐實，致減其彈性作用。

石塊路開始鋪砌以前，路工應將廳線比照路面拱度，約每間十公尺或十五公尺用廳線彈齊鋪砌時即照此逐行平鋪。

鋪砌彈街路並不成行排列，祇將料之長邊與路中線正交，以次砌平靠緊，其接縫以一公分至二公分爲度。

鋪砌方頭彈街須排成行列，故鋪砌時宜擇料之寬度相同者砌爲一列，石之長邊須與路中線正交。合縫亦以一公分至二公分爲度。

鋪砌小方石路及長方石路時，除逐行砌成並行橫列式外，長方石之長邊須與路中線正交，其短邊合縫應爲前後交錯式。在交叉路處應砌成斜列式。各石塊接縫以愈近愈佳，概以一公分至二公分爲適。鋪砌石塊時，應自路邊砌向路中；交叉路處宜自側石邊向路中勻分砌整。

第四節　造價

茲據上海市價，分別計算各種石塊路之造價如下：

（四）石塊路造價表

I. 彈街路(以一平方公尺計算)

工料	數量	單價元	共價	
			無底腳	碎磚基
彈街	0.14 m³	2.98	0.42	0.42
黃砂	0.14 m³	2.85	0.40	0.40
碎磚	0.21 m³	2.00	0.42	0.42
運費			0.28	0.33
工資			0.18	0.33
工具消耗			0.12	0.30
總計			1.82	2.20

(註)如用煤屑砌上價可減0.40元

II. 方頭彈街路(以一平方公尺計算)

工料	數量	單價元	共價	
			無底腳	碎磚基
方頭彈街	0.14 m³	6.90	0.97	0.97
黃砂	0.14 m³	2.85	0.40	0.40
碎磚	0.21 m³	2.00	0.42	0.42
運費			0.28	0.33
工資			0.24	0.39
工具消耗			0.11	0.29
總計			2.42	2.80

(註)如用煤屑砌上價可減0.40元

III. 小方石路(以一平方公尺計算)

工料	數量	單價元	共價 碎磚基	共價 大石塊基
小方石	130塊	9.45/千	1.23	1.23
黃沙	0.14 m^3	2.85	0.40	0.40
碎磚	0.21 m^3	2.00	0.42	——
大石塊	0.28 m^3	2.35	——	0.69
填縫石片	0.07 m^3	2.86	——	0.20
運費			0.25	0.51
工資			0.45	0.45
工具消耗			0.35	0.38
總計			3.10	3.85

(註)如用水泥黃沙上價應加1.50元

IV. 長方石路(以一平方公尺計算)

工料	數量	單價元	共價 碎磚基	共價 大石塊基
長方石	18 塊	4.00/千	7.20	7.20
黃沙	0.14 m^3	2.85	0.40	0.40
碎磚	0.21 m^3	2.00	0.42	——
大石塊	0.28 m^3	2.35	——	0.69
填縫石片	0.07 m^3	2.86	——	0.20
運費			0.25	0.51
工資			0.45	0.45
工具消耗			0.38	0.40
總計			9.10	9.85

(註)如用水泥黃沙上價應加 1.50元

第五節　修養

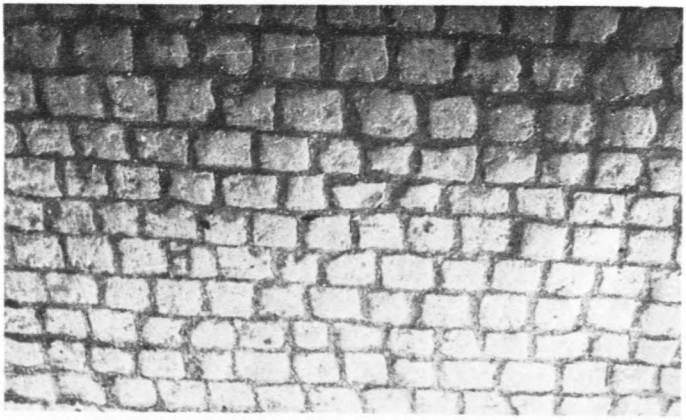
石塊路於各種路面中爲最堅久之路面，故其砌置法得宜者，每不易損壞，亦即毋須修理。其不良於行者，必其底脚之鬆散，致石片或石塊高低不平；或石片之磨蝕，致合縫太寬，因以參差。故於新路築成後，一路交通之繁劇與平庸，即所以定修養期之久暫。上述四種路面，概可自九月或一年修理一次。其修養情形，除彈街路須酌添新料外，其餘石料之須更換者，可謂絕少。即長方石已磨蝕成圓角光面者，僅可另擇一面整平，繼續鋪用，則其修養所費當更減省矣。

第六節　結論

上海堅實之路面雖有冷柏油路、澆柏油路等，但欲求造價低廉，或壽命持久，而修養費減省者，則莫石塊路若。此項材料之產地均距上海尙近，且石塊路之堅強足以抵抗各種重車或鐵輪車，故上海之四郊或碼頭區幾盡屬此等路面。即柏油路上宵爲重車必經之段，或爲簡單鋪砌之手續者，亦往往用石塊砌鋪。重以中國工人技術之優，詢爲中國利用國產造路中最理想之路。惜車行其上隆隆作聲，稍有不平，即生顛簸，乃其缺點耳。茲將石塊路之利害另行分析如下：

石塊路{利——造價廉或較廉，任重持久，修養費省，鋪砌簡單。
　　{弊——車輛行走震動，聲浪多，天雨泥濘。

彈　　街　　片　　路



小　　方　　石　　路

附錄六　上海市之砂石路

上海市工務局

第一節　材料

上海市建築砂石路路面之材料，爲石子與黃泥。石子係閃長石（Trap Rock）之一種，多取之於浙江省之杭州，或江蘇省之松江石山。石質堅硬而有稜角，爲深青色之石子。

石子之大小可分爲五號，最大者爲一號石子，卽時半子；最小者爲五號石子，卽石屑。詳如附表（一）。本市做砂石路時，概用二號三號及五號石子。

（一）石子分類表

號數	名稱	通過篩眼之百分率										
		2½吋 63mm	2吋 51mm	1½吋 38mm	1¼吋 32mm	1吋 25mm	¾吋 19mm	½吋 13mm	⅜吋 10mm	¼吋 6mm	十10號 3mm	十20號 1mm	十30號 ½mm	十40號 ⅜mm
1	半吋子	100	85	35	8									
2	八分子			100	80	20	2							
3	瓜子片				100	80	40	15	5	1				
4	四分子					100	90	60	20	3	1			
5	石屑						100	90	80	60	30	20		

每種石子需要之數量，詳附表（二）。本市十五公分砂石路下層每用一號石子，以代二號石子，以其造價較廉也。

普通建築砂石路每用水凝結法（Water bound），上海附近可採用之石料因缺乏黏性，故多用黃泥以代石屑，此可謂之泥凝結法（Mud-bound）。黃泥之產地在江蘇省蘇州，爲一種極富黏性之黃色山泥，用水混和，卽成極黏之泥漿。

第二節　路基

砂石路之優點，在各個石子經壓實後，仍能融合一體，而傳遞所受之力於各部分，以及於底基。但有時因土基負荷力之不同，雖增加砂石層之厚度，而猶不獲良好之成績，必須有優良之路基爲之承托。上海砂石路所用之底基工程，概分兩種：即碎磚基與大石塊基是矣。

甲、碎磚基　碎磚用純淨碎磚，有缸片泥塊以及其他雜質者，概剔除之。於運到工作地後，即用鋤鏟拉平，其鬆方厚度須爲二十公分，（八吋）迨用六噸或八噸之滾路機滾壓平實，應爲十五公分（六吋。）

乙、大石塊基（Telford Foundation）石料用江蘇蘇州金山或江蘇松江所產山石。每塊至少高二十五公分（十吋，）如底面之寬度或長度小於十五公分（六吋，）或其重量不滿二十二公斤（五十磅）者，概剔除之。填縫料用較小石片，但其品質應與大石塊相同。鋪砌大石塊基時，大面貼泥土基，銳角向上。排砌時宜由路邊鋪向路中，所有縫隙即用小石片一一滿嵌，面層並用小石子掃縫。鋪竣後宜用夯柱夯打，或用滾路機滾壓堅實之。

第三節　鋪築砂石路

砂石路之鋪築現用兩種方法：即甲、濕結法與乙、乾結法是矣。茲分述之：

甲、濕結法　路基鋪築完工後，即將石子分兩層鋪填其上。第一層先鋪一號或二號石子十公分（四吋）厚，經用鋤鏟勻平後，乃灌澆厚黃泥漿，務使所有空隙滿注泥漿，然後用十噸以上之滾路機滾壓，經壓實至八公分（三吋）然後再接築第二層。此項黃泥漿預在路旁做一黃泥坑，或用木板做成木框，實黃泥其中，加以適當之水量，徐徐攪和，使成糊狀，即可應用。

第二層石子用二號，亦鬆鋪十公分厚（四吋。）先用鋤鏟勻平，澆以清水，用十噸以上滾路機滾壓，並撒布三號石子，以填實空隙；俟路面滾壓平整，再加灌厚黃泥漿至飽滿爲度，乃續用十噸以上滾路機滾壓，以將總厚度壓至十五公分（六吋）爲適；然後撒

布石屑一批。待路面凝結乾硬後即開放車輛行駛。有時於撒布石屑之次日，尙須澆洒清水，再用滾路機滾壓一次，然後通車。

乙乾結法　此種砂石屑之鋪築法亦分兩層，第一層鋪一號石子十公分厚（四吋），上撒鋪黃泥一批，乾壓平整後，接鋪二號石子十公分（四吋）厚，再加黃泥一批，經滾壓後，復加瓜子片一層，然後加清水用十噸以上滾路機重壓，以壓出泥漿爲止；然後撒布石屑一層，俟至乾結後，再加滾壓，或即開放車輛，任其通行，藉輪胎之壓滾以堅實之。

第四節　造價

茲據上海市價，分別計算砂石路之造價如下：

表價造路石砂（二）

甲　砂石路碎磚基（每平方公尺價格）

工料	數量	單價	共價（元）
八分子	0.17m³	3.20	0.54
瓜子片	0.03m³	4.10	0.12
石屑	0.02m³	2.40	0.05
黃泥	0.10m³	2.45	0.25
碎磚	0.21m³	2.00	0.42
運費			0.32
工資			0.38
工具消耗			0.39
總計			2.45/m²

乙　砂石路大石塊基（每平方公尺價格）

工料	數量	單價	共價（元）
八分子	0.17m³	3.20	0.54
瓜子片	0.03m³	4.10	0.12
石屑	0.02m³	2.40	0.05
黃泥	0.10m³	2.45	0.25
大石塊	0.28m³	2.35	0.66
運費			0.58
工資			0.38
工具消耗			0.32
總計			2.90/m²

第五節　修養

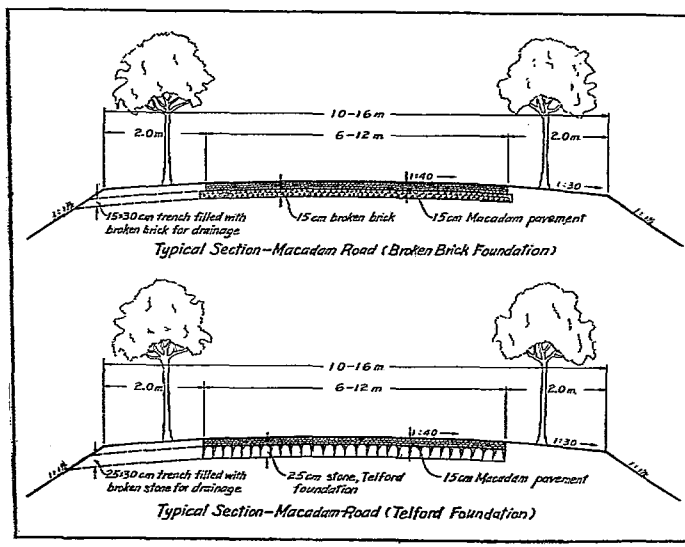
新路建築完成後經若干日月因車輪之磨擦及衝擊經凝固堅壓之石子乃有相互擦擊與離散之機會此種作用一經開始路面漸由小潭車轍潰散而成較大之面積。斯砂石路之所以重修養也。砂石路損壞情形之大小，與車輛交通之繁劇與否成正比例；但車輛稀少之處，有時因雨水過多，經沖刷後，而速其離解者，亦往往有之。故本市之砂石路類多有重車之經過，每於面層加澆柏油以保固之。至其保養費用，亦應視交通情形而異。即就本市修養所費而論，亦甚有等差，如不澆柏油之砂石路，大概於新路完成後四個月，必須修理一次；如建築後適經冬令，不幸而雨雪交融，而車輛又復雜沓，則其修理之時期尚須縮短。要在主持工程者能相機應付之。

修理砂石路時，無論小潭或整塊，其修補處浮散之石子，必盡行舍去，另補新料。其挖掘深度至少應有五公分（二吋）。如須將路面全部翻修者，則應先用鐵鎬將路面挖鬆，然後將舊料用篩篩去浮泥或其較小之石子，如在規定篩眼下保留之料，苟其稜角等並無損傷，仍可援用。所有加鋪石子泥漿或黃泥以及滾壓等築法，概與第三節相同。茲不贅。

第六節　結論

砂石路為用多量之石子鋪砌於土基或其他路基之上，經壓實固結後，即成為平坦之路面，此種道路之在上海，造價固廉，取材亦易，故郊外道路以及住宅區間之市街頗多用之，惜其平坦有餘，而堅固不足，即加澆柏油後，保養亦頗耗費；蓋石子既由各個小體結合而成，其凝結安定之力一失，即潰散而成潭，設現潭穴後而猶不克禁止重車之通行者，全路面之必須重行翻築，實無疑義。故照上海情形言，普通砂石路已不若前二三十年之盛行，其散見於各城鄉道路者，均已澆蓋柏油，或採為灌柏油路或冷柏油路之中間層。雖其單獨之建築已較退化，但與其他固結面層合作而成之路面，每能減輕底脚工程，其效用猶未可厚非也。本市所用之乾結法與濕結法，除乾結法可省去洶黃泥漿之人工外，餘均相同。茲為更求砂石路功用明顯起見，特再分析如下表：

砂石路
- 利——造價廉，取材易。
- 弊——修養費大，雨後泥濘，不適於重車往來，多灰塵。


10-16 m
2.0m
6-12 m
2.0m
1:40
1:30
1:15
15-30cm trench filled with broken brick for drainage
15cm broken brick
15cm Macadam pavement
1:15
Typical Section-Macadam Road (Broken Brick Foundation)
10-16 m
2.0m
6-12 m
2.0m
1:40
1:30
1:15
25-30cm trench filled with broken stone for drainage
25cm stone, Telford foundation
15cm Macadam pavement
1:15
Typical Section-Macadam Road (Telford Foundation)

附錄七　上海市之瀝青路面

上海市工務局

總　　論

上海市建築瀝青路面，向所習用者，有二種方法：

(1)澆柏油法(Surface Dressing)

於砂石路基上澆瀝青二次，即開放通行車輛。

(2)灌柏油法(Penetration Method)

於砂石路基上加五公分青石子，灌瀝青一次，加面層瀝青一批。

除上列二法外，近因交通日趨繁重，並謀道路之整潔起見，於瀝青路之建築方法，力求改善，同時於建築費用方面，仍求其經濟，遂有冷拌柏油法之採用("Cold mix"Bituminous Surface Treatment)。此項方法，係以瀝青及石子不經高溫度，由機器拌合，鋪於砂石路基或混凝土路基。與現在各國所用之柏油砂路面(Sheet Asphalt)，功效相彷彿，而較便利又經濟。

茲將上列三種瀝青路面建築方法，分述於下，以供研討。

第一節　材料

甲・澆柏油路面所用材料為(I)瀝青及(II)石屑，其性質如下：

(I)　瀝青(Residual Bitumen)

(1)　比重(Specific gravity) 77°/77°F.　　1.02

(2)　貫入度(Penetration) 77°F.,　100 gr.,　5 sec.　　40—50

(3) 韌性(Ductility) 90

(4) 揮發性(Volatility) 1.5%

(5) 融解點(Fusing Point) 130°F

(6) 引火點(Flash Point) 475°F

(7) 瀝青純粹性(Total Bitumen, Soluble in CS_2) 99.9%

(II) 石屑

經過10mm(3/8")篩眼而留於3mm(1/8")者 45%

經過 3mm(1/8")篩眼而留於1.25mm(20m sh) 35%

經過1.25mm(20mesh)篩眼者 20%

N・瀝青混凝土路面應用本案：

(I) 瀝青 性質與前同

(II) 石子

(1) 八分子：

經過38mm(1 1/2")篩眼而留於32mm(1 1/4")者 15%

經過32mm(1 1/4")篩眼而留於25mm(1")者 60%

經過25mm(1")篩眼而留於10mm(3/4")者 25%

(2) 六分子：

經過32mm(1 1/4")篩眼而留於25mm(1")者 10%

經過25mm（1″）篩眼而留於19mm（3/4″）者　35%

經過19mm（3/4″）篩眼而留於13mm（1/2″）者　40%

經過13mm（1/2″）篩眼而留於10mm（3/8″）者　15%

(3) 四分子：

過經19mm（3/4″）篩眼而留於13mm（1/2″）者　10%

經過13mm（1/2″）篩眼而留於10mm（3/8″）者　40%

經過10mm（3/8″）篩眼而留於 6mm（1/4″）者　30%

經過 6mm（1/4″）篩眼而留於 3mm（1/8″）者　20%

(4) 石屑 （與前同）

[illegible]：

(I) 冷溶油（"Cold Mix" Flux）係由(1)瀝青加輕柏油（Light Tar Oil）或由(2)煉柏油（Refined Tar）加瀝青茲將其製法分述於下：

(1)由瀝青製成者：材料爲瀝青與輕柏油

（A） 瀝 青 性質與前同

（B） 輕柏油 性質如下：

(a) 比重 60°F　0.983

(b) 水份　0.3%

(c) 引火點　154°F

(d) 柏油酸(Tar acid)　7.0%

(e) 溜解度(Distillation Range)

在177.0°C	開始分解
193.5°C	10 %
203.5°C	20 %
210.0°C	30 %
215.0°C	40 %
221.5°C	50 %

製法：——先將瀝青蒸至 300°F 以上，但不得過 375°F，使完全蒸解變成水泥之流質，待其冷至 200°F 以下（約經過五小時之久），乃將已配合妥成份之壓柏油加入。配合成份，以重量爲標準，爲瀝青90%，壓柏油10%。（冬季井時，另加液蒸油(Liquifier Oil)（參閱下項說明）之故，將成份變更爲95:5）。此項所製成之冷蒸油之性質：

(a) 比重　77°/77°F　1.027

(b) 引火點　239°F

(c) 定炭素(Fixed Carbon)　9%

(d) 灰(ash)　0.5%

(e) 瀝青純粹性(Total Bitumen, Soluble in CS_2) 99.0%

(f) 溜解度：　水份　極微(trace)

0°—200°C　1.4%

200°C--270°C	10%
殘餘物(Residue)	88.6%

(2)由煉柏油製成者：煉柏油(Refined Tar)係由原柏油 (Crude tar) 內提煉至240°C 而得，然後於煉柏油內加入瀝青及輕柏油之混合物，其成份爲：

煉柏油 75%
瀝　青 80—85% } 25%
輕柏油 20—15% } 100%

由此法所成之冷溶油其性質如下：

(a)	比重		1.165—1.200
(b)	引火點		120°F—130°F
(c)	揮發性		4—6 %
(d)	瀝青粹純性(Soluble in CS_2)		80 %
(e)	定炭素		30 %
(f)	灰		2.5 %
(g)	溜解度	200°C	1.25%
		270°C	11.50%

(II) 柏油粉(Pulverized Natural Asphalt)

(a)	比重	1.26

(b)	貫入度	1—2
(c)	溶青純粹性(Soluble in CS_2)	72 %
(d)	融解點	260°F
(e)	定炭素	24.7%
(f)	灰	23.5%

(III) 石子　用松江辰山石子，以質料堅硬不染泥質者爲限，底層(Base Coat)用六分子，面層 (Top Coat) 用二分子，其級配成份如下：

(1)六分子：

經過32mm(1¼")篩眼而留於25mm(1")者	15 %
經過25mm(1")篩眼而留於19mm(¾")者	35 %
經過19mm(¾")篩眼而留於13mm(½")者	40 %
經過13mm(½")篩眼而留於10mm(⅜")者	10 %

(2)二分子：

經過13mm(½")篩眼而留於10mm(⅜")者	5 %
經過10mm(⅜")篩眼而留於 6mm(¼")者	25 %
經過 6mm(¼")篩眼而留於 3mm(⅛")者	50 %
經過 3mm(⅛")篩眼而留於 2mm(1/16")者	20 %

以上之級配成份，以視交通之簡繁，及鋪築之厚度而變更之。

(IV) 石粉　即普通之青石屑經過1.6mm(1/16")篩眼者，便可使用，須無雜質而以乾燥者爲限。

(V) 液溶油 (Liquifier Oil)此項油僅用於天氣寒冷時，使拌時不感困難，鋪起亦感便利。其成份(以體積計算)：

輕柏油	50%
煤　油	50%

煤油之揮發性，須擇其揮發大者，其性質如下：

(a)比重	(77°/77°F)	0.729
(b)溜解度	86°—208°F	26%
	86°—248°F	53.6%

第二節　路基

澆柏油，灌柏油，或冷柏油路面，本市現多建築於砂石路上，此項砂石路之底脚，或爲碎磚，或爲大石塊。惟在表面繁盛處，冷柏油路面，則築於二〇公分(8")厚之水泥混凝土上。此項砂石路之建築方法，已另詳砂石路篇，茲不贅述。

第三節　築法

甲　澆柏油(Surface Dressing)路面建築方法：

砂石路基須乾燥，路面掃刷乾淨，所有泥灰完全掃去，至露出石子爲止。乃澆以瀝青，瀝青須熱至275°F—350°F 即完全爲水狀方可使用。澆時路面溫度不能低於50°F 瀝青以每平方公尺用二・八公斤（即0.5 gal. per square yard.）之比例澆鋪，用柏油噴皮刷掃平。同時酒二分子(由石屑內篩去1.25mm (20mesh)內眼者)一薄層，每立方公尺酒八〇平方公尺。即用八噸滾路機滾壓三次，壓實後，可澆第二次瀝青，先將該路面灰塵及一切鬆動石子掃刷乾淨，路面仍須乾燥。第二次所用瀝青每平方公尺用一・六公斤（即0.35 gal. per sq. yd.）同時即酒石屑一薄層，仍用八噸滾路機壓實後，即可通行車輛矣。

乙　灌柏油 (Penetration Method) 路面建築方法：

於砂石路基上鋪五公分(2")厚八分子加六分子嵌填空隙，砂石路基上之泥灰亦須掃清。用十噸滾路機壓實，自路邊徐徐滾至中心，再用六噸滾路機滾平。路冠(Crown)爲1:40所用瀝青須熱至275°—350°F，然後用九立脫(Liter)(2gal.)裝之20cm (8") 扁嘴鐵壺澆灌路面溫度須在 50°F 以上，每平方公尺須澆瀝青八・一公斤(卽1.5 gal. per sq. yd.)澆時工人二名自路兩邊斜澆(與路線成斜角)至中心，隨時卽洒四分子一薄層，卽用十噸滾路機滾壓堅實。壓實後須將路面掃清，凡路面上所有未黏着之石子及石粉均須掃去，然後預備澆面層瀝青 (Seal Coat)。此項澆法係用柏油橡皮刷工具，先將熱瀝青傾注於路面上，以柏油橡皮刷括平，須括刷勻淨，不能遺留太多。每平方公尺約需四・二公斤，隨卽洒乾石屑一薄層，乃用十噸滾路機壓實後，卽可開放通行車輛矣。

丙　拌柏油石子 (Plant mix "Cold") 路面建築方法：

(I) 機拌 (Plant Mix)

(1)『冷拌』(Cold mix) 機器，茲略爲說明於下：

(A) 石子升降器 (Stone Bucket Elevator)

石子斗容量，可裝石子四分之一公噸，其升降利用吊重機，以適合子捽制之，吊至五公尺高處，將石子傾注於石子儲儲器，以候拌用。

(B) 冷溶油盛器及柏油箱 ("Cold mix" Flux Bucket and Kettles)

盛器容量爲五介侖，四周鐵板爲夾層，中蓄水汀，以保持該器之溫度。器中設浮標一塊，依冷溶油所需分量而定標識。盛器之外，接以輸送管，管分來回二道，管外均包以水汀管，使冷溶油不致有凝結於管中之弊。輸送管之他端，接以五匹馬力馬達幫浦。冷溶油由柏油箱內打入輸送管，由輸送管儲於盛器。柏油箱二只，可置冷溶油五噸；箱內裝五公分水汀管二十道，如此則溶解瀝青，可較迅

速。

（C）拌合器(Mixer)

拌合器容量爲〇·二〇立方公尺（七立方英尺），四周鐵板均爲鍛鋼(mild steel)，中有平行地軸二根，拌槳八塊，槳頭(Shoes)爲五角形之鐵板，斜裝於槳臂（arms）上成45°角，藉可減少拌合時之阻力。槳臂可用鑄鐵，(Cast iron)槳頭用鑄鋼(Cast Steel)，較爲堅固。

（2）拌合方法：

先將引擎及拌合器內拌槳旋轉之速度校正，即引擎每分鐘爲一二八轉，拌槳每分鐘爲三九轉。然後將乾燥之石子傾入拌合器內，同時即澆洒液溶油，（天熱時不用，即加冷溶油，）約歷二十五秒鐘，乃加冷溶油，待其完全拌和，約歷一分鐘，然後加柏油粉，再經三十秒鐘，加石粉，待完全拌和後，即開門放下，裝入卡車，運至工作地點。每斗約拌二分半鐘至三分鐘，冬季拌時略長，每斗約拌四分鐘至五分鐘。每斗重量約爲四分之一公噸。

茲將冬季（溫度在32°F—45°F）所用成份如下：

底層：	六分子	90·84%
	冷溶油	3·59%
	柏油粉	1·59%
	石　粉	3·98%
	液溶油加入數量爲冷溶油之15%	
面層：	2/5四分子	86·02%
	3/5二分子	

冷溶油　5·02%

柏油粉　2·39%

石　粉　5·97%

液溶油加入數量爲冷溶油之13%

（II）鋪築　此項柏油路面分二層鋪築——底層與面層，鋪築厚度，須視壓實路面若干厚度而定。如鋪築五公分壓實路面者，則底層鋪五·六公分厚（每公噸鋪十二平方公尺），面層須鋪二·五公分厚（每公噸鋪三十平方公尺），如鋪三·八公分（一七）壓實路面者，則底層鋪四·四公分厚（每公噸鋪十五平方公尺），面層須鋪一·九公分厚　每公噸鋪三十五平方公尺）

未鋪築之前，須將路基掃刷乾淨，泥灰應完全掃去，路基如有不平之處，則須先補平，（可用拌柏油石子補平）。於窨井自來水管蓋等四周，以及茄莉側石邊等處，均須塗稀薄冷溶油一層。然後將『冷拌』柏油石子用卡車運至工作地點倒下，以人工耙平至所需厚度爲止。如無側石人行道之路，則在未鋪築柏油石子之前，先於路兩邊依照所需之路面寬度而釘立木條子。木條子尺寸，應視所鋪柏油石子路面之厚度而定。路冠（Crown）爲1.40路冠板（Camber）常平準使用。底層鋪平後，將七噸二滾筒滾路機（Tandem Roller）滾壓，自路邊向中央直滾，並須套滾，以半滾筒爲限。滾時速度以每小時滾壓面積不得過一八〇平方公尺，滾筒須常濕潤，以免柏油石子黏着。路面全部壓過一次後，再用十噸滾路機滾壓（Three-wheel Roller）滾法如前。滾過一次後，再用七噸滾路機壓平。凡滾路機壓不到處，須先用鐵板磨光，再用鐵夯夯平。底層壓實後，乃鋪面層。未鋪之先，於側石邊及窨井蓋等處四周，須再塗稀溶冷油一層，然後鋪面層柏油石子，照規定厚度鋪築，耙平後，乃用七噸及十噸滾路機依次滾壓，滾法如前，以尤緩尤佳。路面如有凹孔，則須隨時補塞填平滾實；凡滾路機壓不實處，仍用鐵板磨光，鐵夯夯實。路面壓實後，洒以石粉一層，每立方公尺約洒三〇〇平方公尺，洒後須隨時掃勻，再用輕滾路機滾光，卽可開放車輛通行。

第四節　建築費

下列各表以每一平方公尺計算，價格爲上海市二十二年度市價。

澆柏油路面

材料	數量	單價	價值
瀝青	4.4 公斤	0.112元	0.493元
石屑	0.02m^3	2.40	0.048
人工	0.10工	0.50	0.050
運費			0.010
養路極工			0.008
工具及消耗			0.041
總價			0.650

灌柏油路面

材料	數量	單價	價值
瀝青	12.3 公斤	0.112元	1.378元
八分子	0.05 m^3	3.20	0.160
六分子	0.02	4.10	0.082
四分子	0.02	4.20	0.084
石屑	0.02	2.40	0.048
工資			0.190
運費			0.160
工具消耗			0.188
總價			2.300

"冷拌"柏油石子路面

材料	數量		單價	價值		備註
	5公分厚路面	3.8公分厚路面		5公分厚路面	3.8公分厚路面	
六分子	0.057m^3	0.045m^3	4.10元	0.234元	0.185元	
四分子	0.009	0.008	4.20	0.038	0.034	
二分子	0.014	0.012	3.40	0.048	0.041	
石粉	0.004	0.004	2.40	0.010	0.010	
瀝青	4.617kg	3.800kg	0.112	0.517	0.426	
輕柏油	0.633	0.539	0.260	0.165	0.140	
汽油	0.300	0.261	0.212	0.064	0.055	每介侖爲0.60元
柏油粉	2.123	1.743	0.160	0.340	0.279	
運費				0.170	0.130	
工資				0.210	0.170	
工具消耗				0.304	0.230	
總價				2.100	1.700	

第五節　修養

甲　澆柏油及灌柏油路面修養方法：

澆柏油路面，損蝕頗大，每半年須修補一次，每隔年或須澆瀝青一次。灌柏油路面則較佳，三年後將開始損蝕，則以後須積極修補。此項二種路面，每至夏季，路面瀝青溶化，依照每年紀錄報告路面最高熱度爲150°F。在此時期路面須常洒黃沙或石屑，以便行駛。每一立方公尺約洒面積150平方公尺。洒後即派工人掃勻。又每日須灑水二次。

修補方法：將所壞者挖齊，加石子瀝實，乃澆灌瀝青，面上撒以石屑，滾壓堅實。此項所澆瀝青，每致有太多之弊，應加注意。

乙　拌柏油路面修養方法：

自新路面築成後，每日須派工掃勻路面石粉，並所有石子或碎屑遺留於路面上者，須一概掃除。

修補方法：將毀壞者挖出，四周切齊，以拌好之柏油石子填補。但事前須於路基及毀壞處切齊之四周，應塗稀薄冷溶油一道，然後填入柏油石子，夯壓堅實。（修補面積大，須用滾路機滾實）須較路面略高。面上洒滿石粉，壓實後，即可通行矣。冷拌柏油石子，用作修補材料，頗屬相宜。因拌好後，堆置一旁，隨時可以取用，頗爲便捷也。

第六節　結論

澆柏油路面工程費頗省，惟修養費大，路面容易損蝕，不能載多量車輛。以其建築費省，故於交通簡少之處，仍多採用。

灌柏油路面建築費較貴，但壽命較久，並能載多量車輛。於交通較繁之處，頗見功效。惜於夏季路面瀝青溶化，黏熱難行，須洒黃沙或石屑之麻煩。

『冷拌』柏油石子路，在中國尚鮮建築。此項路面，於雨水較多之城市，尤屬相宜，因不致有傾滑之虞。且較現在各國所用『熱拌』柏油石子路（Sheet Asphalt）經濟又簡便。茲將其優點列下：

（1）機器設備簡單。

（2）所用瀝青成份較省，約較『熱拌』可省25%。

（3）可以隨時鋪築，冬季嚴寒仍可進行，因鋪築時毋須保持相當溫度也。

（4）在微雨後亦可鋪築。

（5）雨後無傾滑之危險。

（6）所用之冷溶油，如使之熱，祇費一小餘時之時間，已可完全溶解。

劣點：

（1）完成之路面不能如柏油砂路面之光澤。

（2）開放初期時，路面往往有重車輛印痕之弊。

（3）初期路面易爲漏油汽車之汽油或機油所損壞。

附錄八　青島市市區各式道路之建築及修養方法

殷宏準
何培禎

第一節　各式道路之建築及價值

青島市爲岡陵地，地質堅硬，凡開闢道路，其土沙底或石底已甚穩固，其上即可修築路面，惟遇山坡深溝，須挖土塡土，另作路基，茲將建築方法及價值分述如下：

甲　開闢路基

一釘樁　按照平面圖規定路線，所有中線邊線，均須誌以木標。寬度最小半徑爲三十公尺，並按照斷面圖在中線木標上記以塡土或挖土之深度。

二平基　挖高處之土塡低處之地。倘若低地附近有土用之較爲省費者，可以利用。另將高處之土，棄置於附近低地內，仍須平墊整齊，不能有高下不平之狀態。塡築路基每塡一尺，打夯三遍，必要時可用水澆潤，以期堅實。塡土之坡度爲一比一又十分之五，挖土之坡度，若遇鬆土爲一比一又十分之五，若遇硬土爲一比一，若遇岩石爲四比一。

三壓路　土路基修成後，用十噸以上之汽碾滾壓堅實。縱坡度在鄉區者，最大不過百分之十五，在市區者，最大不過百分之八，橫坡爲三十分之一，兩旁須留水溝，底寬二十公分至六十公分，上寬六十公分至一公尺，以備疏洩路面之水。

四價值　闢路挖土一立方公尺，價約二角；墾石一立方公尺，價約一元；二百公尺以內運塡沙土一立方公尺，價約一角五分。

乙　修築沙石路面

一平墊路基　若係新開路，可按前法將路基平墊妥實；若係舊路翻修，可先將路面刨起，剔除廢土，將舊石子平墊於路基內，用十噸以上之汽碾滾壓堅實，使路基之橫坡度爲三十分之一。

二鋪石子　先將四至七公分之石子，堆於路邊，俟路基平墊妥實後，即將該項石子鋪於路基上，約厚十五公分，先以十噸以上

之汽碾滾壓一遍，再令水車噴灑路面，汽碾接續滾壓。隨後有兩名長工查驗，若有高低不平之處，即用鐵鍬剷除，高處補於低處，直至滾壓堅實至厚十公分爲止。

三鋪土沙　先將黃沙堆於路邊，俟石子滾壓堅實後，即將土沙撒於路面上，用汽碾乾壓一遍，再灑水一遍，接續滾壓直至將土沙壓成白漿爲止。

四掃除餘料　所有路面殘餘之沙土石子等項，一概掃除淨盡。

五價值　每平方公尺工料費五角。

丙　沙石路面改修油路

一覺定路基　將路面掘起約深十公分，剔除沙土及無稜角之石子，棄置他處；其有稜角之石子散布於路基上，用十噸以上之汽碾滾壓堅實。若發現路基有鬆軟之處，須多用石子或亂石填築至堅實爲止。路基之橫坡度爲五十分之一。

二鋪設石子　鋪設徑四至七公分石子一層，約厚十二公分，用十噸以上之汽碾滾壓，並不時洒水，使石子穿插堅固，滾壓至碾前不起微波爲止。汽碾滾壓時，隨後須有富有經驗之工人兩名各持鐵鍬一張，勻鋪石子，不使稍有高低之處，並以一公分左右之石屑撒布一層，嵌入小縫，用汽碾壓實路面。壓好後橫坡度仍爲五十分之一，路面築成厚十公分。

三一次澆油　美孚出售之JGK各級柏油，合衆公司出售之E級柏油，亞細亞出售之穿度四十五之柏油，均可應用。在路面乾透後，使用柏油前，須將柏油裝於特製之油鍋內，去皮加火，約須熬至八小時，用水銀表伸入油內，驗看是否熬到發光點，普通熬至攝氏表三百度以上五百度以下，以各種柏油說明書所載之度數爲定。熬至度數後約在午前九點，即可開啓鍋後機閘，俾柏油流滿一鐵桶，兩人扛至工次，另有兩人各用長柄鐵勺舀出揚散，以蓋遍石子爲度，不使有過淡過濃之處。每平方公尺，約澆油八磅左右。另有兩人各執鐵鍬散布乾淨之海沙，以蓋遍柏油爲度。另有兩人用火滾一個，徐徐滾壓，使油沙黏結，若有露油之處，即再以沙蓋之，然後用重碾滾壓七八遍。

四二次敷油　第一次敷油後，准許車馬過行，約一星期後，將海沙掃淨，即行刷油。法用鐵勺將油舀去，倒於路面上，用棕刷塗刷，以勻淨爲度。每平方公尺約用油四磅左右，隨蓋以淨沙，用火滾滾壓，並用五噸汽碾滾壓五六遍。約歷兩週後，即可將浮沙掃除。

五價值　每平方公尺約需工料費一元一角。

丁　修築小方石路面

一平墊路基　按照前法平墊路基。

二鋪砌小方石　小方石係花崗質，寬十六長十八厚十五公分，尺寸稍大稍小，均可應用。鋪時下面須墊以細沙。方塊石之縫最大不得過一公分，均須灌以細沙。鋪砌完工後，尚須用重碾滾壓妥實。壓過之後，若有凹下之處，須將塊石提高，下面用細沙墊實。

三價值　每平方公尺約需工料費二元四角。

戊　修築石條路面

一平墊路基　按照前法平墊路基。

二鋪砌石條　石條長六十公分至一公尺五十公分，寬三十二公分，厚十五至十七公分，用上等花崗質。上面鑿路，每長一公尺內約五十道。下面用細沙墊實。對縫不得寬過一公分，概用細沙灌實。

三價值　每平方公尺約需工料費二元四角。

己　修築石級

一平墊路基　先將基地闢成斜坡，約一比二之坡度，並在兩旁壘砌短牆。

二安設石級　先由下端向上安設。石條之下面墊以五公分厚之一比三比六之混凝土，將石級平鋪其上，兩端放於短垣上，如

此逐步安設，直至頂端爲止。石級之外緣以寬三十公分，厚二十公分之石條。每一堦段之四角，均埋立高四十公分三十五公分見方之石條。所有石縫，均須用一比二水泥漿扦縫。

三價值　每長一公尺約需工料費一元二角。

庚　修補油路面

一挖補　破碎較深之坑，須將舊石子挖出，使周圍邊際之深度，垂直坑底，將徑四至七公分之新石子填入，用夯打實，用二至四公分之小石子灌縫，仍用夯打實，再澆灌熔好之柏油，每平方公尺約八磅。柏油之上面，蓋以石屑，用火滾滾壓，再用夯打實。破碎較淺之坑，可先用棕刷掃淨灰塵，布石屑一層，再澆灌柏油，每平方公尺約六磅，蓋以粗沙，用火滾滾壓堅實。

二敷油　全路或全段修補竣工時，再掃除浮動之沙子石子等項，而撒以熔好之柏油一層，每平方公尺，約四磅左右，完全無缺之處，可不撒油。撒油之處，一律蓋以淨沙，火滾滾壓之後，用五噸碾滾壓，以堅實爲度。雨過後掃除淨沙。

三價值　挖補柏油路面，每平方公尺約需費一元二角，敷油每平方公尺約需費六角。

辛　修補沙石路面

一挖補　先將破碎較深之坑，挖出舊石子，使坑之周圍深淺，直垂坑底，將徑四至七公分之新石子填入，夯實並潑水。

二鋪沙　待全路修補竣工後，一律蓋土沙一層，撒水用汽磙滾壓，以壓出白漿灌入石縫爲度。

三價值　挖補沙石路面每平方公尺約需六角。鋪沙每平方公尺約需費三分。

第二節　材料工資及工區工隊等項之處理

一材料取得及價格　道路材料如緣石（Curb stone）溝石（Gutter stone）車軌石（Stone track）瀝青油（Asphalt）由市政府購辦委員會招標購買外，土沙海沙僅有採費運費，並無其他價格，石子（四公分至七公分）由石子商承辦，每立方公尺，單價自一元二角至二元，運費在外。

茲將各種材料價格及運費列表於后：

尺寸	名稱	單位	單價	運費	備註
1m×.35m×.15m	綠石	公尺	1.20元	.20元	安設工及運費在內
1m×.40m×.15m	青石	公尺	1.20	.20	安設工在內
1m×.50m×.10m—.20m	車軌石	公尺	1.20	.25	同上
3mm—7mm	石子	立方公尺	1.20—2.00	0.30—1.00	
2mm—4mm	石子	立方公尺	1.50—2.30	0.30—1.00	
石渣	小石子	立方公尺	1.70—2.50	0.30—1.00	
	海沙	立方公尺		0.30—1.00	拾工在內
	土沙	立方公尺		0.30—1.00	挖工在內

二工資　工頭日支八角至一元四角，機匠八角至一元三角，最工四角至一元，短工三角二分至四角，均於月終一次支給。馬車（車及一夫一馬）一輛每日一元五角五分，水車（僅有一夫一馬本局自備馬車）一輛每日一元六角四分，以上兩種車馬人夫，均由車商供給，每月結算一次，每年招標一次以定價單。

三包工與自辦　凡應募辦工程，由臨時費項下開支，以前所述，均爲臨時工程辦法，由工務局繪製圖樣，造具預算工程說明書及標單，呈請市府核准，發交購辦委員會，招商投標，由該會簽訂合同，發交工務局，由工務局派員監工，自開工之日起，每三十日發

給已經完成工料費百分之七十至八十，臨時費由工務局呈請市政府轉飭財政局核發，結零及尾數，俟驗收後付清，凡歲修工程，多係自辦，即由工區指派工匠工人照工作時間舉辦，工資及材料，在經常費項下開支，以後所述者，均經常工程也。

四工區組織及修養情形　本市區內道路之修養分配於兩工區担任之。每工區設主任一人，監工若干人，工頭若干人，工匠及長工若干人，短工則臨時僱用。第一工區因地位衝要，交通較繁，其轄各種道路面積約一百二十萬平方公尺，大部爲柏油路；第二工區共轄各種道路面積約一百三十萬平方公尺，多沙石路面，均長期組有工隊維持道路。

五工隊織組　工隊之組織，視修補路面之多寡而定工數，通常以工頭一名司其事，率長工若干名，機匠（汽碾司機）二名，短工（臨時僱用）若干名，水車一二輛，馬車（運石子土沙及廢土）若干輛，汽碾一具，攜帶工具工作；若爲滙青路，則並須攜帶油鍋火爐。

第三節　近五年來修養修築路面之成績

一　修養沙石路面積

年份	修養面積	備考
十八年	二，七三五，〇三七平方公尺	
十九年	二，八一一，〇一二平方公尺	
二十年	一，九五三，一七九平方公尺	
二十一年	一，九八八，六六〇平方公尺	
二十二年	二，二二五，八四六平方公尺	

二　修補柏油路面積

年份	修補面積	備考
十八年	二九，四〇八平方公尺	
十九年	一一〇，四七九平方公尺	
二十年	一四二，九三九平方公尺	
二十一年	三七，一八三平方公尺	
二十二年	二九，六八五平方公尺	

三　修築沙石柏油路面積

年份	沙石路面積	柏油路面積	備考
十八年		五七，九〇七平方公尺	
十九年	五，一二〇平方公尺	四六，一五一平方公尺	
二十年	六二，二七七平方公尺	二五，九〇一平方公尺	
二十一年	二一，四三一平方公尺	五〇，〇三一平方公尺	
二十二年	三一，〇九〇平方公尺	一八，六一二平方公尺	

第四節　結論

青島市區因地勢關係，所有道路，傾斜太甚；且地屬海濱，風多雨急，沙石路修築雖較價廉，但因土沙凝結力不固，每遇風雨，輒被

冲洗吹刷，路面易於毀壞，在交通繁盛之路，每年須修補四五次之多，即次要之路，亦二三次不等，是築路費用雖廉，而維持殊屬不貲。柏油路修築價昂，然維持極省，亦無冲毀路面及淤沙積貯雨水斗（Catch Basin）之弊，且清潔美觀，於交通衞生兩有裨益。再者本市宜用柏油路有特殊情形，因地質堅固，無需修築路基。其造路面所需之材料，如石子爲本地所產之花崗石，最爲堅硬，海沙在附近海灘採取，質料堅固，沙粒大小成宜，均屬價廉物美，故修築柏油路較爲適宜，而現有之成績亦覺顯著。並訂有十年計劃，因限於經濟，未能逐步實現。至小方石修路，於本市坡度較大之道路，亦最相宜，且作法簡單，路基僅用海沙墊平壓實，不須另用石塊及水泥建築，載重四五噸之車輛通行其上，亦無損壞之虞；惟此項路面，須費究亦較多，故多數路面仍以碎石土沙鋪修。爲求沙土之凝結力較固，路面壽命較長起見，最近試用海灘城土，與土沙攙合，其成分爲一比十（一成城土十成土沙）及一比十五，鋪於碎石之上，約厚二三公分，洒水壓實，路面甚屬平整，其粘結力亦較大，風時吹刷不易，雨後因沙質成份較多，亦不甚濘泥，此後無論市鄉沙石路面擬均用此法修築，亦本市改良路政之一端也。

附錄九　青島市鄉區道路之建築及修養方法

嚴宏淮
何培禎

第一節　各種道路之修築及價值

(一)土路修築　本市鄉區山林幽邃，果木繁多，或以風景絕佳，遊人麕集，或以物產豐富，商旅頻繁，是以修築公路，爲發展本市當急之務。築路之初步，爲開闢土路基。係就鄉村與市政或工廠或學校或名勝地域，或村與村間之原有小道，測量路線，修築開闢或展寬至五公尺以上，作法與市區同。路冠(Crown)爲一與二十五之比。旁留水溝，若經過山坡深溝之處，爲防止雨水冲刷起見，須分別鋪砌條石，壘砌路牆，栽植防險石樁。每長一公里之距離，樹立里程石一根，標明里數，路之起達點及二路交點各樹方向石一根。村落分段維持路面之處，樹分界石一根。除挖土塡土鋪修路面水溝，均由民夫担任工作，不計費用外，其餘工程需價如左：

1	開除岩石	每立方公尺工料費約七角
2	壘砌路牆	每平方公尺工料費約八角
3	石　樁	每一根工料費約一元四角

(二)路面修築　凡交通繁盛之道，有修鋪沙石柏油及條石路面者其作法與市區同。

第二節　各種橋梁涵洞水井水壩修建及價值

(一)橋樑涵洞　查本市鄉區，山多地少，是以所修道路，對於洩水方法，極爲重要。凡橋梁寬度在二公尺以上者爲橋，小於二公尺者爲涵洞，而因所用材料及建築方法不同，該項橋梁涵洞又分爲若干種類，茲分別述之：

(1)河底橋(Ford)　本市河道因地勢高峻，淤沙甚多，故雨水不能停留，秋夏大雨時，河面有多量之水，然雨過後，水即洩去，餘留極細。凡道路經過河溝平闊之處，類皆不設高橋，而用條石鋪砌河底，名爲河底橋。大雨時水由橋上漫過，並酌留暗

洞以洩小水，此爲本市鄉區特有之建築，尙屬因地致宜，且甚經濟。其建築方法，因地勢及水勢情形而異，大抵先將河底掘挖至相當程度，用亂石及混凝土疊砌橋基，每隔一·二至一·六公尺砌橋托石一道，用洋灰固結，上安凵形橋卡石，再上安橋板石，約與河底平。橋寬通常約三公尺，故橋板石多屬寬三·二公寸，厚二五公寸，計九列。兩側用亂石砌寬一公尺之護坡，兩端砌橋翅，亦有因河底集沙甚淺，地基堅固，而不用亂石砌基或不用橋托石者，其餘構造方法相同。該項橋每長一公尺約需工料費三十元。

(2)**拱橋**（Arch）凡路綫越過深溝之處，以建築拱橋爲宜，其建築方法及孔數隨地勢情形而異，通常就孔之內綠言，分矮拱半圓拱橢圓拱等類。施工時，先將兩端橋基挖至硬底，用亂石疊砌至地平面後，再用亂石或整塊石疊砌橋牆（即拱根座）至應需高度，即按應需拱橋之形式，用木料或石塊作拱胎，然後在兩橋牆頂牆安拱根石條一列，再綫拱胎安設拱石，至拱頂中心安拱冠石一列，均用混凝土固結，然後用土填平或鋪橋板石。並疊橋頂擋牆，經過兩星期，即將拱胎拆除之。此項拱橋，如係石質，每立方公尺約需工料費十元。

(3)**平橋** 石造橋亦因地勢長度不同，而建築方法各異。通常將橋基挖至硬底，用亂石及洋灰漿疊砌牆基，用亂石或方塊花崗疊砌橋墩。至相當高度後，安置凵形橋卡石，用混凝土固結，然後鋪設橋板石。此項橋板石隨需要情形，分鑿面與荒面兩種，荒面橋板石，上層覆以泥沙與路面情形相同。又此項橋板石如係橫置，其下用鋼梁或鋼軌架荷之，亦有多數橋梁疊砌橋墩後，用混凝土及鋼骨作橋板，而不用其他石料者。此項石橋，每長一公尺約需工料費三十元。

(4)**涵洞** 涵洞分圓涵洞方涵洞拱涵洞三種，隨地勢，水勢及應用材料而分別建造之。圓涵洞或用混凝土製成橢圓形之長管，連接安設之，或用瓦管連接埋置之，其大小尺寸隨經過水量而異。方涵洞之製造與平橋相似。拱涵洞有石造及混凝土造二種，造法與拱橋相似，惟形式較小而已。

(二)行道樹 凡寬度在五公尺以上道路，兩側栽植刺槐或楊柳，此項樹苗由農林事務所培養分發村民栽植，並由該所派員指導

之。

(三)水井　本市山多河乾，灌溉行道樹及洒路甚爲困難，故宜於公路經過地點開鑿水井，以利工事，且可供飲料之需。該項水井，或由本局自鑿，或招商承辦。通常井口徑約八十公分，井底徑約一公尺，井深隨地質及水源而異，但水深至少在二公尺以上。井身用青磚或亂石壘砌，靠近井底部份，用柳枝編織墊底，井口處用亂石及混凝土砌井台高五十公分，三公尺見方，上面用水泥墁平，並用一：二：三混凝土作高五十公分厚十公分井圈，坎入井台上，以防污水流入井內。鑿井工料平均每深一公尺，約需費十五元，井台及井圈每座約二十五元。

(四)擋水壩　本市山多，每值秋夏雨期，山洪暴發，隨山澗而下，冲塌田地廬舍公路經過之處，亦每被冲毀，斷絕交通，故須沿山澗急流之處，建築擋水壩，以保田廬。此項水壩作法，大半就河道急灣地點，掘挖壩基，使與水勢成四十五度角，用大塊亂石及混凝土壘砌至水平面後，再用亂石及混凝土壘砌壩身，其兩側坡度爲一比一。此項工程每立方公尺，約需工料費四元，但材料搬運，由民夫担任不計費。

第三節　調用民夫及工料等項之處理

(一)民工出夫辦法　本市鄉區公路，近年完成較爲迅速，端在利用民力。凡新修各路，均由村民分段担任開闢路基，運送材料工作；惟鑿除石崗，建造橋梁涵洞之大工，如石匠兎匠等由工務局僱工辦理，出夫辦法，係按工程情形，由工區招集工程附近各村莊之村長首事等人開會，按照各該村戶口或地畝之數目平均劃分段落，辦理之，除鰥寡孤獨，無力服務者可不担任工作外，其餘均須出夫，或每二人中抽派一人，或每若干畝地抽派一人，由本局監工率領分赴工場工作。

(二)石料取得及價格　鄉區修路材料，以花岡石子，亂石及條石爲最多，均係就工場附近開採。石子每立方公尺，價洋約八角，亂石約七角，條石每立方公尺約十元，鑲面條石約二十元，均係就場交貨。每項工程購料如不超過三百元，即由工務局招商投標承辦，如在三百元以上，例由工務局先行佈告招標，呈請市政府派員前往監視開標，以標價最低者爲合格。

(三)每公里土路修築費　鄉區道路因經過之地勢情形不同，至關路工作難易不一，而所需費用及調撥民夫數亦因之而異。大致寬五公尺之土路，平均每公里之築路（指橋梁涵洞之建築及石崗之開闢，石樁之安置）費二百七十元；調民夫數，每公里約一千二百工。

(四)工區組織及修養方法　工務局就鄉區各地劃分爲五工區，每一工區設主任一人，監工工頭長工各若干人，與市區工區略同，但人數較少，每日視工事之繁簡，在修養範圍以內，由主任支配監工率領工頭及長工組織若干工隊，帶同應用工具，分赴各工場工作。鄉區道路約二百四十萬平方公尺，除主要幹路爲柏油與砂石路外，餘均係土路。修養方法：柏油路及砂石路與市內同。其他所需材料工匠，均由工區預備。土路及沙石路，每年分春秋二季，大舉鋪壓土沙，以維路面。此等工作（挑土担水鋪壓）係招民夫爲之。每年修養費每公里約九十元。

第四節　結論

查鄉區道路在民國二十年以前，計有寬四公尺以上之馬路十八條，共長十八萬二千公尺；二十一及二十二兩年份中，計修築寬五公尺以上之馬路六十九條，共長十九萬六千公尺。其餘修築嶗山一帶之石級人行道，及加寬舊有馬路之工事，尙未計入。前後相較，其進展情形，尙屬顯著。所以有此成績者，端在政府與人民甚能合作，惟材料與石工由公款開支，其他土工運料等項均由民夫担任。且交通便易之利益，於治安商運行旅諸事，充分表現，深入鄉民之腦際，倘有倡導築路者，莫不樂於爲之，今後當更無難事。若政府經濟裕如，再行分別緩急，從事補充，且逐漸改善，則本市鄉區道路網之計劃，即可成矣。

附註　上載青島市報告兩篇，因寄到較遲，未及編入本國總報告內，附此聲明

The maximum height limit for vehicles including trucks, buses and coaches is 3.75 m. Double-decked buses are not much used in China.

(c) The overall length for commercial vehicles minus trailers shall not exceed 10 m. including the body and loads. For combinations of vehicles, the maximum overall length is limited to 18 m. including the body and loads. For single-decked buses and coaches, it is limited to 9 m.

2. The maximum limitations as laid down by these regulations are to insure safety of traffic, but they tend to limit the use of heavier trucks on the highways.

3. International unification of these regulations is necessary from the point of view of automobile trade as a whole. China will undouotedly favour the idea of unification provided it is based on fair, practical and economical principles for all countries concerned.

Conclusion

In the first place, unification of regulations in regard to the weight, width and length of vehicles will be beneficial to the administrative authorities in so far as it helps to clarify traffic problems which are fast growing in China. Secondly, it offers as a good guide to automobile dealers who will likely have a fair knowledge as to what to improve in order to suit our needs. Lastly, in view of the points mentioned, the unification of regulations in one locality will, in the long run, hasten and promote international unification which, if realized, would change many phases of the modern motor world.

VI. 1. WHAT ARE THE REGULATIONS AT PRESENT IN FORCE REGARDING:

(a) the weight permitted in respect of vehicles (laden or unladen);

(b) the width and height of vehicles and their loads;

(c) the length of vehicles and their loads.

2. CRITICAL ANALYSIS OF THE ADVANTAGES AND DISADVANTAGES ACCRUING FROM THESE REGULATIONS.

3. IS IT DESIRABLE TO AIM AT INTERNATIONAL UNIFICATION FOR THESE REGULATIONS?

IF SO, WHAT SHOULD BE THE BASES FOR SUCH UNIFICATION?

The motor vehicles in China are mostly concentrated in large cities and on the highways that serve to connect these cities. Before the Inter-Provincial Traffic Commission was organized in the fall of 1932, no two cities or provinces had common regulations to control motor vehicles. Each locality formulated its own regulations and carried them out independently. Since the Commission came into being, the existing regulations were carefully studied and revised in an effort to standardize and unify them. As the organization is growing, the regulations will in near future be applied in all parts of China when more roads are constructed and more automobiles are introduced to serve the public. The unified regulations for buses and coaches have already been in force, but those for other kinds of motor vehicles have yet to be promulgated. The following articles are, in part, extracted with regard to the weight, width and length of the vehicles:

(a) The maximum laden weight permitted is 12,000 kg. for good surfaced roads inside the towns as specified by municipal regulations and 7,500 kg. for highways. The unladen weight for the latter is about 3,000 kg. No restrication is made on unladen weight of chassis, but no vehicle shall be loaded in excess of the factory rating.

(b) The maximum overall width for vehicles other than buses and coaches is 2.50 m. and for single-decked buses and coaches is 2.40 m. The track of the front and the rear wheels shall be as near the same as possible and shall not be less than 70% of the maximum overall width.

(5) Adoption of restrictive measures against dilapidated cars;
(6) Provision of ambulance and other first aid equipments.

Under the present conditions in China, native carts are still in use in the open country. On account of the clumsiness of their construction and slowness in their motion, their presence on the roads imposes not only heavy expenses for the maintenance of roads but also a great hinderance to the fast moving motor traffic. To remove such objections, the building of separate stone paths for the exclusive use of native carts along with the modern motor roads has been recommended.

(c) At Level Crossings

In order to promote safety of traffic at level crossings the following devices are recommended:

(1) Installation of danger signs;
(2) Installation of railway gates attended by gatekeepers;
(3) Direction of traffic by traffic polices.

Other expensive means of grade separation such as the construction of overhead bridges or the under-paths, will be undertaken whenever they are justified by the increased volume of traffic. When the crossings are located at places far away from built-up areas, the installation of automatic signal system seems to be necessary. A proposed system of automatic signal light has been contemplated by the Commission and will be recommended for use at points of railway crossings if it proves to be successful.

Conclusion

(1) Traffic regulations should be unified and vigorously enforced.
(2) Education on safety should be given to the drivers, the traffic police and the public.
(3) Highways should be equipped with safety means such as road signs, guard rails, traffic police, etc.
(4) Besides other principles, safety of traffic should be also taken into consideration in designing roads.
(5) Motor vehicles should be constructed in conformity with safety requirements. Dilapidated or unsafe cars should be prohibited on the roads.
(6) Emergency measures such as first aid provisions should be given equal attention.
(7) Greater attentiveness on the part of pedestrians and motorists should be emphasized.

(a) In Towns

In promoting the safety of traffic in towns, we should aim at separating as much as possible the traffic between pedestrians and vehicles and between vehicles themselves. By so doing, the chance of contact is reduced, and so is the chance of accident. In order to solve this problem, first of all, it is necessary to widen the narrow streets. Secondly, sidewalk space should be amply provided. Most of the city government authorities in China have taken definite steps toward laying out city plans and providing regulations governing setback in building constructions. At the same time, the necessary widening of streets has been carried out to a great extent in large cities.

For streets where widening has not yet been done, the following emergency measures have been adopted:

(1) To restrict the use of such streets for one-way traffic;

(2) To apply restriction on certain vehicles at certain hours for periodically congested streets.

As possibility of accidents is great at intersections, the following means have been provided:

(1) Traffic police to direct traffic;
(2) Standard traffic signs;
(3) Isles of safety and marking of safety zones;
(4) Construction of squares or traffic circles.

The most difficult problem seems to be the control of pedestrians from crossing streets at places other than intersections. As vehicles generally slow down when approaching intersections, careless crossing in the middle of a block is something that fast moving vehicles are not prepared for and that involves possibilities of accidents.

The speed limit is set very low in China, owing to the existence of narrow streets in most Chinese cities. Consequently, the occurrence of accidents has been quite few. The efficiency of automobiles running at high speed has, however, been greatly curtailed.

(b) In the Open Country

In the open country, where traffic is light and high speed of vehicles is attainable, the following steps have been taken to insure the safety of traffic:

(1) Reduction of grade at crossings to a minimum;
(2) Improvement of poor alignment along the existing highways;
(3) Construction of guard rails at dangerous sections;
(4) Installation of standard road signs;

(a) Traffic Facilities

Traffic facilities of one nature or another have been provided on many roads. To mention but a few of them, they are the installation of standard road signs and traffic signals, the employment of traffic police and police patrols on motor cycles and the construction of guard rails at dangerous places. Other measures such as the grade separation, the elimination of sharp curves, the widening of narrow bridges, etc., will be carried out as soon as the volume of traffic warrants such actions.

(b) Restrictive Measures

Restrictive measures against dilapidated motor vehicles to move on the roads have been adopted. At the same time strict inspection of motor vehicles has been conducted by traffic authorities at specified intervals. The Commission is also looking forward to the drafting of regulations governing the compulsory automobile reliability insurance, and make standard design of motor buses.

(c) First Aid Provisions

Emergency measures after accidents have been carried out in accordance with the practice in the western countries. The provision of ambulance in cooperation with hospitals, the supply of first aid boxes in motor buses and the distribution of pamphlets under the title of "what to do after accidents" are some of the steps taken by the Inter-Provincial Traffic Commission.

(d) Educational Work

Concerning the educational work, efforts have been exerted along three directions. Firstly, the public is educated by the distribution of safety charts, the publication of guide books, and the conduct of safety campaigns through newspaper, radio, public lectures, movies or lantern slides. Secondly, for the education of the drivers, the establishment of training schools and the publication of drivers' guides have been under preparation. Thirdly, to educate the traffic police, instructions and lessons on traffic and regulations have been given. Indeed, there are numerous educational measures which can be applied and tried in order to remove the causes of accidents on the part of road users.

As regards the specific questions in relation to the particular means adopted to promote the safety of traffic in towns, in the open country and at level crossings, they will be discussed in the following paragraphs.

sion of the Three Provinces of Kiangsu, Chekiang and Anhwei and the Two Municipalities of Nanking and Greater Shanghai was organized in the fall of 1932. One expert from each of the Provinces and Municipalities concerned is to be delegated to the bi-monthly conference of the Commission. As these delegates are more or less in direct charge of traffic control in their respective provinces and municipalities, the decisions made at the conference usually carry so much weight that important measures can be easily and promptly put into execution.

Considering the promotion of traffic safety as one of its important duties, the Commission has initiated many activities along this line. Many regulations and rules have been drafted and passed by the Commission such as road traffic regulations, rules governing the registration and taxation of motor vehicles, rules governing the unification of road signs and rules governing the issuing of drivers' licenses. As to the measures for the promotion of safety of traffic, they will be dealt with elsewhere in this report.

(2) Road Signs

Road signs of different designs have been used on the roads in different provinces. Naturally it would cause great inconvenience to the motorists to travel on the inter-provincial highways. With a view to facilitating the inter-provincial traffic, unification of road signs was considered as an important step toward the promotion of the safety of traffic. Therefore, in the first conference of the Inter-Provincial Traffic Commission a resolution was adopted to use the international road signs with a slight modification to suit the local condition. Since then the provinces have all been following these standard designs for their road signs. For the convenience of motorists, the Commission has also unified the designs of milestone, of directional signs, and of numbering plates of roads, bridges and culverts which are to be established on the inter-provincial roads.

(3) Means Adopted to Promote the Safety of Traffic in Towns, in the Open Country and at Level Crossings

Many unified means and measures to promote the safety of traffic have been adopted by the Three Provinces and the Two Municipalities. They may be described under the following headings:

(a) Traffic facilities
(b) Restrictive measures
(c) First aid provisions
(d) Educational work

IV. MEANS ADOPTED TO PROMOTE THE SAFETY OF TRAFFIC:

(a) in towns;

(b) in the open country;

(c) at level crossings.

LEGISLATION; REGULATIONS; ROAD SIGNS.

Foreword

The necessity of the promotion of the safety of road traffic in China has been emphasized by the increase of highway mileage together with the increase of motor vehicles during the last few years. Since the opening of traffic of the interprovincial highways in the year 1932, it is all the more important to provide safety means on highways in order to minimize the possibility of accidents. Recently joint activities in this direction have been witnessed in the Three Central Provinces of Kiangsu, Chekiang and Anhwei in coorperation with the Two Municipalities of Nanking, the new capital of China, and Greater Shanghai, the largest commercial city in the Far East. In fact, some sort of safety means for road traffic has been more or less provided in different provinces since they started to build their highways. But the coordinative action between provinces and municipalities toward the promotion of the safety traffic is certainly a new advancement in China. The unified means for such purposes by the Three Provinces and Two Municipalities, we venture to hope, would extend to other provinces and eventually the whole of China. It is thus deemed proper to describe in this report some of the activities undertaken by the respective provinces and municipalities.

(1) Legislation and Regulations Governing the Safety of Traffic

Rules and regulations governing motor traffic have long been in force in different provinces and municipalities. As they were made by different legislative bodies, lack of uniformity is the natural consequence. When the inter-provincial highways in the provinces of Kiangsu, Chekiang and Anhwei were open to traffic in the year 1932, great inconvenience was felt by both the travelling public and the governing bodies. In order to facilitate inter-provincial motor traffic and to unify such rules and regulations, a joint commission by the name of Inter-Provincial Traffic Commis-

additional patrol should follow each rain, to restore the binder to the surface and act as a protection to the road metal.

(b) *Repairing.* Repairing by either the dry method or the penetration method should be made wherever the road surface shows a sign of deterioration. The old aggregates, which are usually rounded, should be replaced with new aggregates which are angular and hard. The repairing usually does not have to go deeper than 3-5 cm. Careful connection should be made with the old portion.

(c) *Drainage.* It is important that good drainage is provided for the clay bound macadam. Grass in the ditch should be cleared away and blind drains in the shoulders should be well maintained. The crown of the surface is usually made 1 in 20.

Cost

The cost of the clay bound macadam varies from $0.36 per square meter to $2.90 per square meter in Chinese currency in accordance with the design and the local costs of labor and material. The respective costs of each type in different localities are given in the last table.

The cost of maintenance varies from $150 to $300 a year for each kilometer.

Conclusion

(1) The clay bound macadam is a low cost type of pavement suitable for modern traffic. It does not corrugate as the gravel road, nor does it deteriorate as the water bound macadam.

(2) The clay bound macadam can be maintained to give good service for many years. Under heavy traffic bituminous surface treatment have been applied with satisfactory results.

Clay Bound Macadam-by the penetration method-Chekiang, China.

Clay Bound Macadam-by the Dry Method-Hunan, China

Clay Bound Macadam-by penetration method-Nanking, China

carried on to saturation. After the grouting of each course, it should be rolled. After the grouting of the top course, finer aggregates are applied to fill up the voids as rolling comes along. Stone chips are then spread over the finished surface and the road is ready for traffic. Some specification may require sprinking with water and rolling on the next day, before the road is open to traffic.

Materials

Rocks of limestone, sandstone, quartzite or trap rock are used for broken stone. For the bottom course, 3-6 cm. aggregates, well graded, should be used. In the case of the Experimental Road built by the National Economic Council at Nanking where a 12 cm. bottom course was used with no foundation aggregates as big as 8 cm. were allowed. For the top course, 2-4 cm. aggregates conforming to required gradings should be used. Aggregates of ½-2 cm. size are used as filler and stone chips should be screenings of 6 mm. or less.

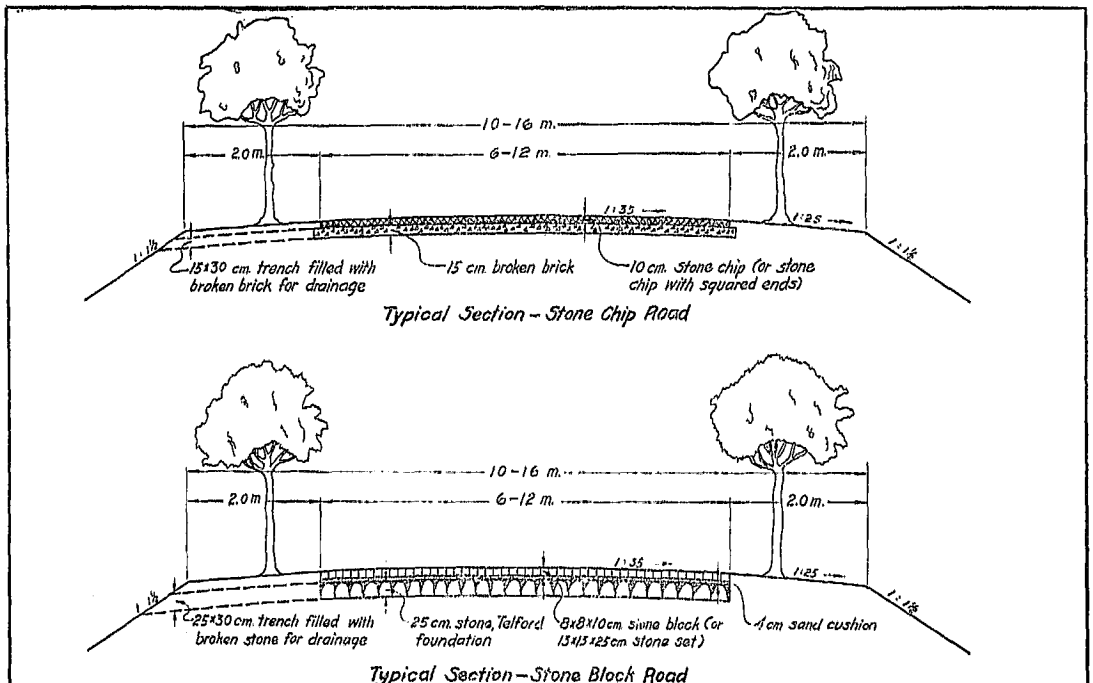
In Hunan province, there is a wide distribution of sand and gravel, which are used instead of broken stones. In such cases, higher percentage of clay is required in the bottom course according to the report of the above province.

The clay used is generally yellow or red clay. The fact that it is available in most part of China explains perhaps why the clay bound macadam is widely adopted. There is no specification regarding the quality of clay except that it should be pure clay free from foreign admixtures.

Maintenance

That clay bound macadam is better than water bound macadam lies in the fact that it is easier to maintain for a longer and better service. The clay, besides acting as a binder, furnishes a kind of embedment to the aggregates and prevents the pavement from deteriorating rapidly. The binding power of the clay and the interlocking between the aggregates act together to stand the shearing force of the wheels of the high speed vehicles. However, it cannot be expected that a road surface would be stronger than its weakest ingredient. The loss of the superficial clay binder due to wind, rain and wheel action would reduce the macadam to a helpless condition in a few months and revelling would then start. It is important therefore that the surface be constantly maintained since its construction. The maintenance work is simple and usually consists of the following:

(a) *Surface treatment.* The surface should be constantly maintained with the application of damp clay sand and stone chips, and


10-16 m.
2.0 m.
6-12 m.
2.0 m.
1:35
1:25
1:1½
1:1½
15x30 cm. trench filled with broken brick for drainage
15 cm. broken brick
10 cm. Stone chip (or stone chip with squared ends)
Typical Section – Stone Chip Road
10-16 m.
2.0 m
6-12 m.
2.0 m.
1:35
1:25
1:1½
1:1½
25x30 cm. trench filled with broken stone for drainage
25 cm. stone, Telford foundation
8x8x10 cm. Stone block (or 13x13x25 cm. stone set)
4 cm. sand cushion
Typical Section – Stone Block Road

Type		Compacted Thickness in cm.				Cost per sq. m.
		Fundation	Bottom	Top	Surface	
Dry Method	Hunan	——	7	5	2	$0.36-0.47
	Shanghai	20 cm. broken brick 25 cm. broken stone	10	10	1	—
Penetration Method	Shanghai	20 cm. broken brick 25 cm. broken stone	8	7	1	$2.45-2.90
	Kiangsu	15 cm. Telford	8	7	1	—
	Nanking	——	12 (1)	7	1	$1.18-1.43

Note: (1) Broken bricks are also used for bottom course.

The dry method. With clay as a binder, the dry method of construction is very simple. The subgrade and foundation course should be constructed in the same way as that in the water bound macadam. The bottom course is laid over the foundation (or over the subgrade if no foundation) in the designed thickness. Clay of approved quality and prescribed amount is then spread over the bottom course and harrowed with hand rakes until a good mix is obtained. Where traffic is light, it is left over for many days till there comes a wet weather when it will be rolled to compaction with a 5-ton roller. If the work is done in a haste, it is sprinkled directly with water.

The finer aggregates used for the top course and the surface dress are usually premixed with clay. The mixture is dampened with water in the process. The top course is laid over the bottom course of mixing and compacted in the same way. The surface dress is then applied and compacted either by traffic or with a light roller of 3½ tons.

In Shanghai, Telford or broken brick foundation is used. In Hunan province, however, more than 2,000 kilometers that are still in good service have been constructed without any foundation. The amount of clay used, according to Hunan report, is 20% to 25% in the bottom and the top courses, and 10% in the surface dress. The clay should be crushed to 3 mm. in size or less.

The penetration method. The clay bound macadam by the penetration method resembles the bituminous penetration macadam in the process of construction except that a grout of clay is used instead.

The grout is prepared out and of good clay alone. It should be as dense as would not affect good penetration. It is applied twice—once in the bottom course and once in the top course, and each application should be

the Tan-Shih surface may have to be repaved in a few years where the foundation is poor, and yet there is always a good salvaging value of the old pavement.

Conclusion

(1) The Tan-Shih and half regular stone block pavements when constructed in a competent way, are at a low cost, making an all-weather and durable type of road surface that is commendable for moderate traffic. The half regular stone block pavement offers better service at a reasonable increase in cost.

(2) The use of a broken brick or a broken stone foundation for the above-mentioned pavements is always advisable. It will prove to be adequate for ordinary subgrade soil even in regions of heavy rain fall if provisions are made for good drainage.

(3) In order to adjust the thickness of the foundation course to suit the subgrade soil and drainage conditions, a 10 to 12 cm. surface course with a 5 to 8 cm. bedding course may prove to be adequate. Larger blocks are more difficult to work with, and thicker beddings do not seem to be more useful.

(2) Clay Bound Macadam

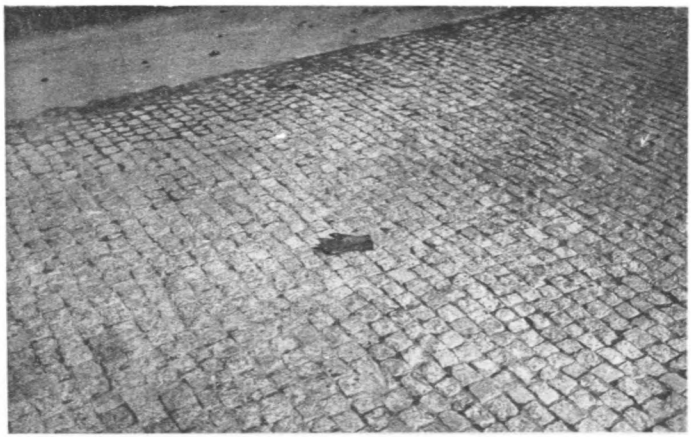
The clay bound macadam, as a low cost surface, occupies an important place in highway pavements in China. It can be easily maintained to serve with good results, while a gravel road or a water bound macadam can not. It does not corrugate as the gravel road, nor does it deteriorate rapidly as the water bound macadam.

Design and Construction

Methods of construction. The simplicity in the method of construction of such a pavement fits well with a low cost road. There are two methods in use, the dry method and the penetration method. Practice varies greatly in different localities. The dry method is commonly adopted in the province of Hunan, while the penetration method is prevalent in the province of Kiangsu.

Designs of Pavement. The clay bound macadam is constructed either with or without a foundation. Over the foundation, the pavement is usually laid in 3 courses—the bottom course, the top course and the surface dressing. The following table represents the typical designs and gives the local costs.

Tan-Shih Pavement at Shanghai, China



Half Regular Stone Block Pavement on the First Experimental Road at Nanking, China

The Bedding Course. After the foundation course is constructed, a bedding course is spread over it with sand, pit sand, cinder or stone chips sieved through a 6 mm. screen. It should be rolled with a light roller, when the thickness adopted is 10 cm. For a thickness of 5 cm. or less, rolling is not required. Bedding course of cement and sand is less used in such types of pavement than in the construction of stone sett and regular block pavements.

Laying the Pavement. In laying the pavement, additional bedding material is necessary to fill in the open voids between the stone blocks. Every piece of stone should be well embedded, leaving as small a joint with the other stones as possible. A straight transverse joint should be maintained from curb to curb and perpendicular to the center line of the road. Considering the irregular shape of the Tan-Shih, it may be realized that rather skillful labour is required to accomplish such a task. The stones are dumped in rows by the side of each paver. As the labour proceeds along, he can with his experience select at a glance the right piece of stone to fit in with those already in place. He can plant it with the right face up so that it gives also a good bearing surface on the bottom. The typical hand tool he uses has a hammer on one end and a small wooden tamper on the other. Now and then, he will give a few chops to the stone to make it fit for a good pavement. In a day's work, an average worker can pave as much as 20 square meters. With half regular blocks, the manipulation is simpler.

Inspection with Rammer. As the laying is going on, inspection of the pavement should be followed with a rammer. Each piece should be tested to a solid bearing. Those laid flat, or unsound in quality, settling down under the rammer or forming bad joints with the rest should be displaced or adjusted to give an even and true surface.

Finishing. After inspection, joint fillers are distributed over the pavement. Usually the same material as used for bedding is adopted. Bamboo brooms are used to sweep them into the joints. Steel pins are sometimes resorted to. The pavement is then rammed again with a thirty kilogram wooden tamper. The tamping starts from the edges towards the center of the road. Sometimes a light rolling follows the tamping. The whole surface is then given a final inspection using templates and straight edges to detect such defects as undiscovered before.

Cost. The cost of the Tan-Shih pavement is $2.2 per square meter, and the cost of the half regular stone block pavement is $2.8 per square meter. The estimate is based upon the current price at Shanghai in 1933.

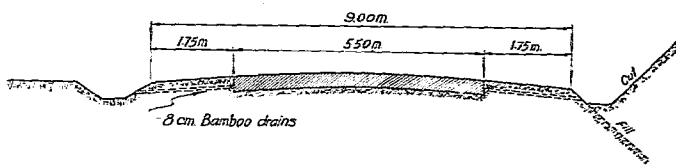
Maintenance. The maintenance cost of the Tan-Shih and the half regular block pavements is very low. A few replacements of the defective stones will be usually sufficient. When there is a large amount of mixed traffic,

cm. square.) The stones should be laid with their lengths perpendicular to the center line of the roadway and their joints staggered.

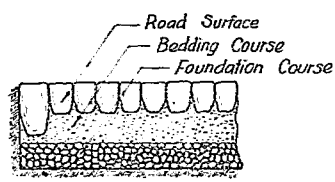
The edges of the pavement are usually flanged with larger stones of the half regular type. They should be as thick as or thicker than the paving stones and about 20 cm. in depth and 25 cm. in length.

Construction

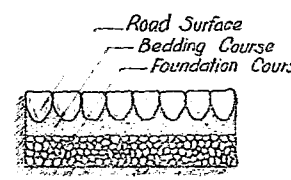
Foundation Course. Foundation course of broken stone or broken brick is constructed in depths of 8 to 15 cm. thick. Higher values of the thickness are used where rainfall is heavy or subgrade soil is poor. On the First Experimental Road at Nanking, a foundation of 10 cm. has proved to be adequate. Its subgrade is silty clay which furnishes fairly good support when dry. Bamboo drains were embedded in the shoulders as illustrated in the accompanying figure.



Typical Cross-section



Half Regular Stone Block Pavement



Tanshih Pavement

One section on the same stretch was constructed with no foundation course. Undulations later developed and the section was repaved with the addition of a 10 cm. foundation. Unfavorable drainage condition is believed to be the cause. The same highway further down from the Experimental Road has been fulfilling its duty with no foundation.

ding course from 5 to 10 cm., and the foundation course from 8 to15 cm. The following table gives the variation in the design according to the practices in different localities.

Type of Pavement		Thickness in cm.		
		Surface	Bedding	Foundation
Tan-Shih Pavement	Shanghai practice	10	10	15
	Nanking practice	10	5	12
	Chekiang practice	10	4	8
	Kiangsu practice	13	5	—
Half Regular Block Pavement	N. E. C. Type I	10	10	10
	N. E. C. Type II	15	5	10

It may be noticed that according to the Kiangsu practice, the foundation course is sometimes dispensed with if the subgrade is satisfactory and the traffic light. On the edges of the pavement, flange stones of larger sizes are used.

Materials. The foundation course is built either of broken stone or of broken brick. The bedding course may utilize such local material as obtainable that can serve the purpose. Usually sand, pit sand, cinder or stone chips are used. Without going into details, it suffice to say that any of the materials used should have a uniform and good quality free from foreign matters. The surfacing stones are composed of limestone, sandstone, quartzite or granite, or other kinds of rock produced in the vicinity and approved by the engineer in charge.

No regular form is required of Tan-Shih. It should have a flat top and a flat bottom surface, parallel or nearly parallel to each other. And when we stand on one of these surfaces, it should not be too oblique. It is not dressed in the usual sense of the word, but it should be chopped of "Stomachs" and "Nosings" so that when placed in position it would not make a joint too open or tend to be unstable under load.

The half regular blocks are roughly dressed to a square form on the top with the top and bottom surfaces as smooth and parallel to each other as possible. The bottom surface should not be less than about 6/10 of the top, and none of the four sides should make an angle greater than 30 degress with the surface. It should be free from "stomachs" and "nosings". The irregularities on the surface are limited to 5 m.m. and those on the sides to 8 m.m. The variation in any dimension should not be in excess or in deficiency of 1 cm. from the nominal size.

The usual depth for the Tan-Shih and the half regular blocks is 10 to 15 cm. The length and width of each piece should not exceed 15 cm. (But for half regular blocks, the top surface is preferably to be 10

Although the Tan-Shih pavement and the clay bound macadam are perhaps, the most common types of road surface both for city streets and for highways in China, the method of construction and the materials used differ widely in different localities. It might be traced back to such causes as materials available for use, climatic conditions, the volume of traffic to be carried as well as soil performances, but never to the detail specifications that provide for such conditions. In the year 1935, the Bureau of Roads of the National Economic Council constructed the First Experimental Road at Nanking and started some study in this matter. There are 7 types of Tan-Shih and half regular stone block pavements in 58 meters in total length, and 4 types of clay bound macadam roads in 47 meters in total length.

This report will treat briefly the three above-mentioned types of pavements in China respectively under the following headings:

(1) The Tan-Shih pavement and the half regular stone block pavement;

(2) The clay bound macadam.

(1) The Tan-Shih Pavement and the Half Regular Stone Block Pavement

Tan-Shih Pavement. Tan-Shih pavement is essentially a crude type of surfacing and possesses all the advantages inherent to its class. It is easy and economical to repair because it can be replaced piece by piece with very little interference to traffic and the old pavement has a good salvage value. By using broken stone in its crude form as paving material, the low cost of such pavement is incomparable to any of its kind. In regions where rainfall is heavy and dirt road is the best to be desired, Tan-Shih surfacing would convert it into an all weather road good for medium and heavy traffic.

Half Regular Stone Block Pavement. The primitive form of stones used in the Tan-Shih pavement is, however, not entirely satisfactory. Its rough riding surface causes much vibration and noise to the car, increases the cost of operation and lessens the comfort of the passengers. Adequate foundation and good drainage can help but only to a certain extent, unless the shape of the paving stone is improved. Hence in the First Experimental Road, half regular blocks have been introduced. The increase in cost over the Tan-Shih pavement is slight and its adoption is feasible.

Design of Pavement. A foundation course and a bedding course are generally used for either the Tan-Shih or the half regular block pavement. The surface course of stone varies in thickness from 10 to 15 cm., the bed-

III. MEANS AVAILABLE FOR THE CONSTRUCTION AND MAINTENANCE UNDER THE MOST ECONOMICAL CONDITIONS OF ROAD SURFACES WHETHER IN BUILT-UP AREAS OR THE OPEN COUNTRY

(1) The methods adopted.

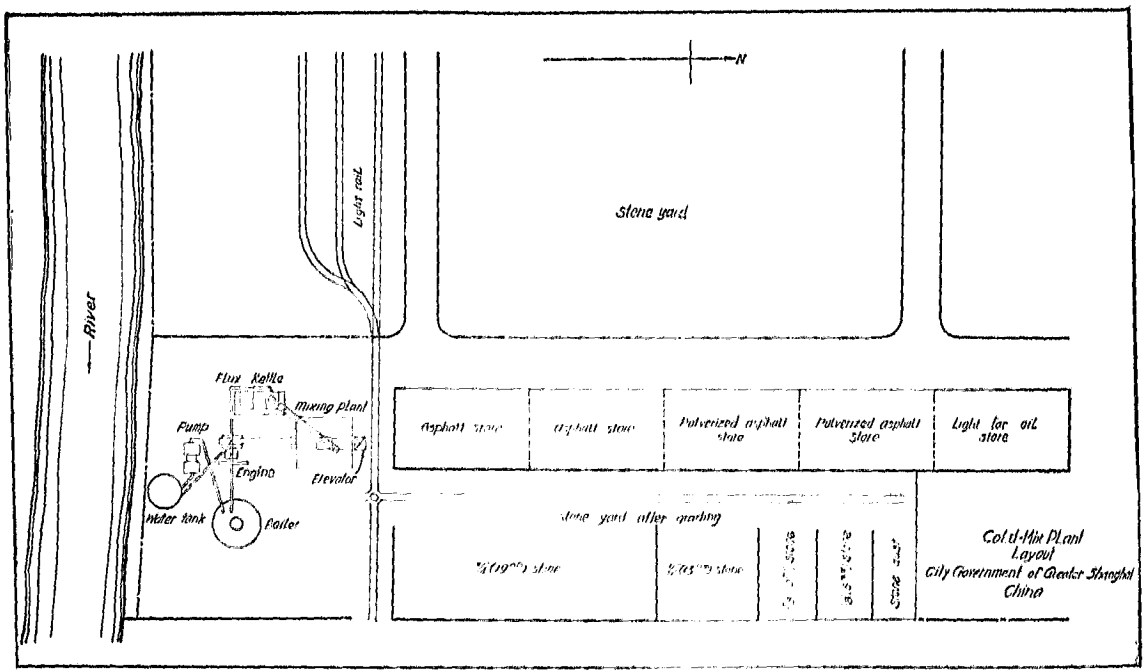
(2) Review of the conditions influencing the choice of method, according to the characteristics of soil and climate.

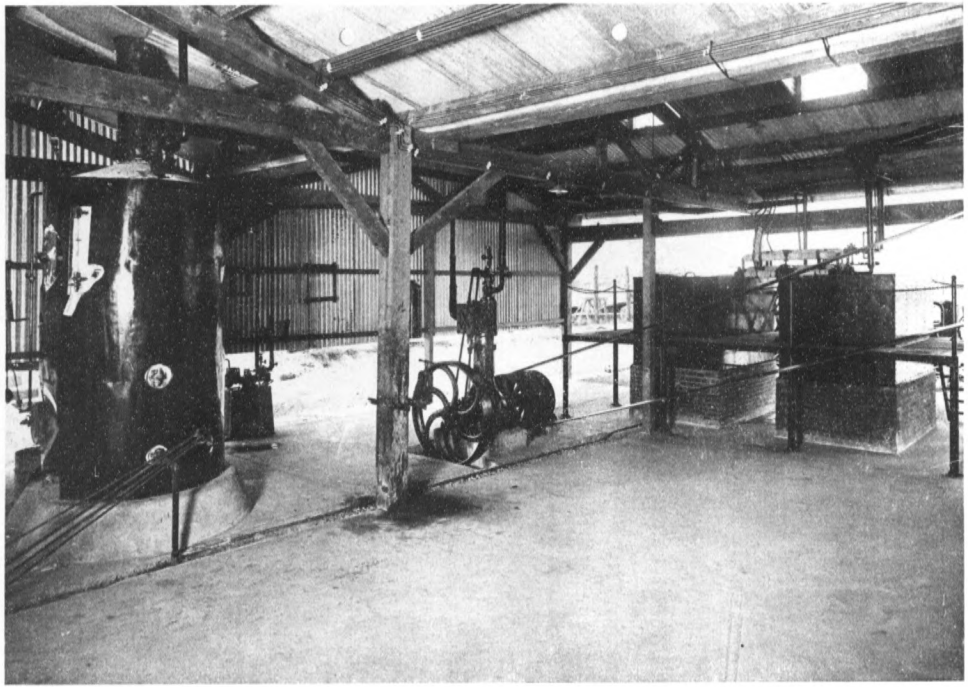
Foreword

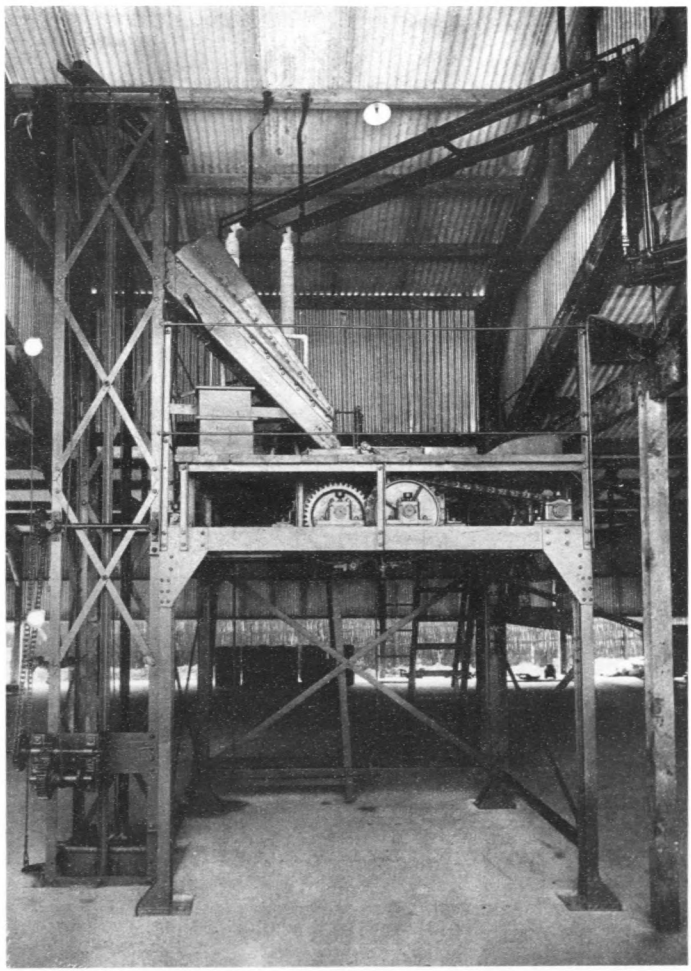
By utilizing local materials for the construction and maintenance of road surfaces, there have been developed in China many types of low cost roads among which the "Tan-Shih" road and the clay bound macadam are the most prevalent.

Tan-Shih pavement resembles cobble stone pavement except that broken stones of 10 to 15 cm. in size are used for the road surface with a bedding course. Usually, a foundation is also provided. The success of such pavement depends largely upon the skill of the workmen on account of the irregular form of the paving stones used. The trend is to try a better form of stones and yet without incurring too much expenses for its manufacture. The idea of half regular stone block pavement has been introduced. An experiment was made on a test road by the National Economic Council. It proves to have a better surface at a reasonable increase in cost.

Clay bound macadam was developed from water bound macadam and has since largely taken its place. In principle, clay is used as a binder and embedment for coarse aggregates. By the name of the material used, however, it should be evident that clay bound macadam could not stand traffic much better than water bound macadam. But clay bound macadam is preferred because it can be easily and cheaply maintained to stand medium and heavier traffic for a long time. The stretch on the Experimental Road constructed by the National Economic Council has carried an average daily traffic of 300 automobiles and 400 animals for over a year without any repairing work. There have been much longer records where a patrolling force is maintained to give timely care to the road surface.


N
River
Light rail
Stone yard
Flux
Rolls
Mixing plant
Pump
Engine
Elevator
Water tank
Boiler
Asphalt store
Asphalt store
Pulverized asphalt store
Pulverized asphalt store
Light for oil store
Stone yard after crushing
Col d-Mix Plant
Layout
City Government of Greater Shanghai
China





the work is completed by a light rolling when the road is open to traffic. The surface of the road when finished has the appearance of crocodile's skin.

The cost of the "cold mix surface treatment" compares favourably with other types of bituminous surfaces and is second only to bituminous surface treatment of macadams. The table on p. 13 gives a comparison of the costs based on the market price at Shanghai in 1933.

Conclusion

(1) The bituminous treatment of clay bound macadams, when carried out at the right of use, i.e., when the road surface has been worn to a mossaic appearance, and with prompt maintenance, has proved to be successful and is considered an economical way of improving existing clay bound macadams.

(2) The advantages of using bituminous emulsions for the surface treatment of clay bound macadam and water-bound macadam are three folded: (1) it is simple to handle because of its cold application; (2) it has high penetration power and applicability in damp weather on wet surfaces and (3) it is less skidding.

(3) The cold mix bituminous pavement costs less than the hot mixed bituminous pavement, the saving in the amount of bituminous materials used being figured at 35%. It requires simpler mixing plant, is easier to construct, and can be laid both in cold weather and in damp weather when the road surface is wet. The road surface is less skidding in rainy days. With careful compaction and timely maintenance, it is considered good for heavy traffic.

The plant layout is shown on a separate cut while the accompanying pictures show the interior view of the plant.

The mixer turns at a rate of 39 r.p.m. yielding one batch in every 2½-3 minutes in warm weather and in every 4-5 minutes in cold weather. Each batch is about ¼ of a metric ton.

Construction

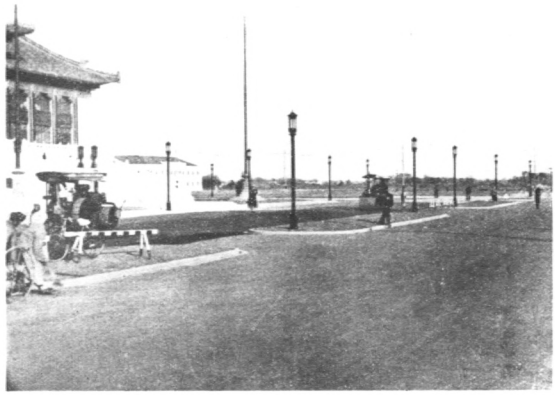
The cold mix surface treatment is laid on a broken stone or a broken brick intermediate course with a Telford foundation. Where traffic is heavy, intermediate course of cement concrete is also used.

The surface is laid in different thickness. When a compacted thickness of 5 cm. is desired, the bottom layer is placed at a loose thickness of 5.6 cm., and the top layer, 2½ cm. When a compacted thickness of 3.8 cm. is desired, the bottom layer would have a loose thickness of 4.4 cm. and the top layer, 1.9 cm. In the former case every metric ton of mixture can cover 12 square meters at a cost of $2.10 per square meter. In the latter case, every metric ton can cover 35 square meters at a cost of $1.70 per square meter. Both of them include the costs of material, labour and equipment.

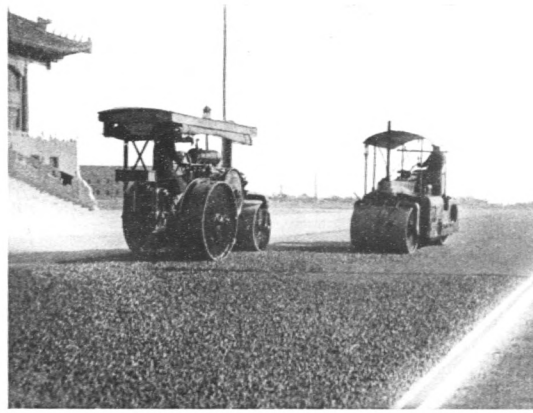
The mixture is trucked from the mixing plant to the site where it is dumped and raked to designed thickness. Each course is rolled separately. The rolling is started with a 7 ton tandem roller, followed by a 10 ton 3-wheel roller and finished again with a 7 ton tandem roller. After the top layer is compacted, stone dust is then applied as a binding material at a rate of 300 square meters per cubic meter. It is swept even and

Type of Pavement			Cost/sq. m.
Surface layer	Intermediate course	Foundation	
5 cm. sheet asphalt	20 cm. cement concrete	25 cm. Telford	$10.40
ditto	10 cm. water bound macadam	ditto	7.10
5 cm. penetration macadam	ditto	ditto	4.90
5 cm. cold mix	ditto	ditto	4.70
3.8 cm. cold mix	ditto	ditto	4.30
Surface treatment @ 4.4 lb./sq. m.	ditto	ditto	3.25

Note: When broken brick foundation is used instead of Telford foundation, the cost will be $0.60 less.



The cold laid bituminous pavement at Shanghai, by the Public Works Department of the Shanghai Municipality.



The cold laid bituminous pavement at Shanghai, showing condition under construction.

(4) Cold Laid Bituminous Pavement

The cold laid bituminous pavement now in use in Shanghai is branded as "cold-mix surface treatment", which mainly comprises the mixing of mineral aggregates with a cold flux and the addition of a certain percentage of pulverized natural asphalt and limestone dust. The pavement is ordinarily laid in two layers of different mixtures. Coarse aggregates are used for the bottom layer and finer aggregates for the top layer. The cold flux used is either a mixture of refined tar, asphalt and light tar oil, or a mixture of only asphalt and light tar oil without refined tar. The properties of the resulting flux as prepared respectively by the first and the second method are given in parallel columns in the following table:

		1st. Method	2nd. Method
a.	Specific gravity 77/77F	1.165-1.200	1.207
b.	Flash point	120°F-130°F	239°F
c.	Volatilization	4-6 %	——
d.	Fixed carbon content	30 %	9%
e.	Ash	2.5 %	0.5%
f.	Total bitumen, in CS_2	80 %	99.9%
g.	Distillation Range:		
	water content	——	trace
	0°-200°C	1.25%	1.4%
	200°-270°C	11.50%	10.0%
	Residue	——	88.6%

In mixing, the aggregates are first introduced into the mixer followed by the prepared (1) flux, (2) asphalt powder and then (3) stone dust in the following proportions:

Top layer:

Aggregates (fine)		86%
Cold flux	6/10—7/10	8%
Asphalt powder	4/10—3/10	
Stone dust		6%
		100%

(Liquefier oil equal to 13% of cold flux to be added in winter time)

Bottom layer:

Aggregate (coarse)		91%
Cold flux	6/10—7/10	5%
Asphalt powder	4/10—3/10	
Stone dust		4%
		100%

(Liquefier oil equal to 15% of cold flux to be added in winter time)

The liquefier oil is a mixture of equal quantities of light tar oil and gasoline; and it is added to the aggregates as the latter are introduced into the mixer. Its function is to produce a better mix of higher workability in cold weather.

In order to adapt macadam roads to modern traffic and yet not to incur so much expenses as the increasing mileage would demand, the water bound method has been developed in a large part of China into a singular type of clay bound macadam. It is quite similar in the method of construction, to bituminous penetration macadams with two treatments using, however, a grout of clay instead. The function of the clay is to furnish largely an embedment to the aggregates, to take up shocks from wheel impacts and to stabilise the former. It has also an appreciable amount of binding power which, coupling with the interlocking action of the aggregates, stands the shearing force from high speed wheels. Altogether, however, it is far from being adequate unless a wearing coat is applied to prevent the loss of the clay binder due to wind and rain and the subsequent raveling of the road surface. It is for this purpose that the Second Experiment Roads was constructed at Nanking by the Bureau of Roads of the National Economic Council of China, on which many classes of asphalt, tar and bituminous emulsion have been tried. The result is quite gratifying as can be seen from the accompanying photo which shows a 2.8 meter single coat surface treatment of a 5½ meter clay bound macadam road that would otherwise be badly torn up.

The surface treatment of clay bound macadams was made a few months after the road was open to traffic and its surface has been worn to a mossaic appearance. The treatment is made either in 1 or 2 applications respectively at a rate of 3 or 4½ kilograms per square meter of road surface. Loose spots are cut into square holes and patched before treatment. The method of construction in details is similar to that used in the bituminous surface treatment of water bound macadams.

(2) Bituminous Penetration Macadams

Bituminous penetration macadam has lately displaced the hot mixed method of construction of asphaltic concrete, where hot mixing plant will be an additional item of cost and where traffic is light. The first application is generally a 40-50 penetration asphalt applied at a rate of 8.1 kilograms per square meter, covered with stone chips, rolled and followed by another seal coat of 4.2 kilograms per square meter. This seal coat is squeezed and covered with stone dust. The surface is then given a final rolling when the road is ready for traffic.

(3) Hot Mixed Bituminous Pavements

The hot-mixed type of bituminous pavements, by which we mean sheet asphalt and asphaltic concretes, is used mostly in cities. The careful control to be exercised in the construction of such pavements and the rather expensive mixing plant required have led to the trial of cold laid pavements in Shanghai.

A 2.8 meter single coat bituminous surface treatment of a 5½ meter clay bound macadam.

II. PROGRESS MADE SINCE THE CONGRESS AT WASHINGTON IN THE MANUFACTURE AND USE OF TAR, BITUMEN AND EMULSIONS FOR THE CONSTRUCTION AND MAINTENANCE OF ROADS

Foreword

The increase of motor traffic in recent years has extensively developed the use of bituminous materials for the construction and maintenance of highways in China. Most of the mileage of such pavements concentrates in large cities and is gradually extending to interurban roads. Following in general the practices adopted by predecessors along this line with some modifications as local circumstances may require, we find no difficulty in carrying out their construction. Only until recently, increasing demand of such pavements is calling for a more economical method of using bituminous materials for the construction and maintenance of roads, which may account for the construction of the Second Experiment Road at Nanking, and the establishment of the new Cold-Mix Central Mixing Plant and the new Bituminous Materials Testing Laboratory at Shanghai by the Public Works Department of Greater Shanghai. The result so far is marked with interest by the city and highway engineers in this country.

The use of bituminous materials for road construction in China has been confined mainly to the following methods:

(1) Surface treatment of earth roads, clay bound macadams and water bound macadams;

(2) Bituminous penetration macadams;

(3) Hot-mixed bituminous pavements, as sheet asphalt and asphaltic concretes;

(4) Cold laid bituminous pavements.

In many instances in the following description, it will be found unnecessary to go into details of the specification of material and the methods of construction since they are developed from the practices of our European or American colleagues.

(1) Surface Treatments

Bituminous materials have been used in China to treat the surface of earth roads, clay bound macadams and water bound macadams. It may be noticed that to surface treat clay bound macadams is an innovation.

6. Edge thickening of cement concrete pavement is effective in strengthening the corners but would not reduce the thickness of the slab beyond what the load would generally allow.
7. Longitudinal joint is useful in preventing irregular longitudinal cracks and also in serving as a guide to the traffic.
8. Equal care should be given to the subgrade of concrete pavement as to that of any others.
   Work by hand labor can be practically as good as machinery work, and can be used to advantage where unemployment is a problem or where labor is less expensive.

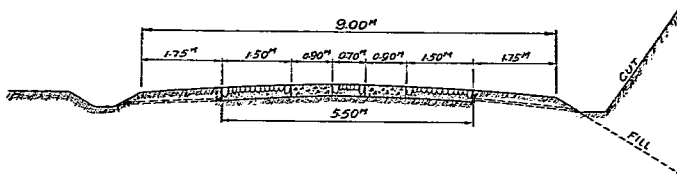


Fig. 3

Cross section of the concrete track pavement, showing the track, the "Tan-Shih" pavements on the center and sides, and the bamboo pipe drains in the shoulders.

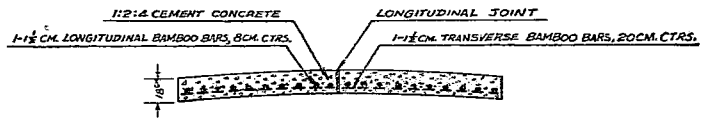


Fig.

A section of the cement concrete pavements showing the longitudinal joint and bamboo reinforcing bars.

Conclusion

1. Cement as highway paving material is becoming popular in China, and in view of the rapid development of highway communication, it has a great future in this country.
2. When fairly hard coarse aggregates are available, single course cement concrete pavement is recommended rather than the 2 course type even with a moderate amount of mixed traffic.
3. Asphalt coating as a protective wearing course on cement concrete pavements does not seem to be necessary.
4. Cement bound macadams without protective wearing surface as now in use can not stand traffic very well. It is, however, considered possible to improve it into an economical type of pavement for light traffic, the sandwich and the penetration methods of construction are recommended for further study.
5. Concrete track pavement with twin trails is less costly than full width slab concrete pavement, and is suitable for regions where an all weather and comfortable road is desired and yet the traffic will not become so dense as to warrant a full 2- lane pavement in the near future. In particular, the center and sides of the track should have a durable type of pavement like Tan-Shih surface and should be provided with good drainage.

a leaner mix of 1:3. Poor penetration as inherited from the method of construction, however, has caused rather rapid deterioration of the surface.

The sandwich method of construction was successfully tried. Leaner mortar of 1:3 and 1:3½ were used on which 5 cm. of crushed stone was spread and rolled until mortar appeared on the surface.

The result is equivalent to a thin pavement of cement concrete which stands the traffic satisfactorily until recently a few transverse cracks have appeared.

(3) Concrete Track Pavement

One track pavement of cement concrete forms another interesting type in the test. Each rail is 90 cm. wide, 18 cm. thick and of plain 1:2:4 mix. They are spaced 70 cm. apart between the inner edges. Expansion joints were spaced 25 meters apart with construction joints halfway between.

The center and sides of the track were paved with "Tan-Shih" surface, which furnishes a rough but solid ride, offers no danger for cars to cross-pass each other, and provides for better drainage over the surface.

Subgrade drainage was taken care of by bamboo pipe-drains as shown in the section. The two accompanying photos illustrate respectively the conditions while under construction and when completed with the "Tan-Shih" surfacing.

This section has been open to traffic for more than a year now. Motorists find no difficulty in driving on it. They can drive at a higher speed with comfort and at reduced operation cost. It is also cheaper to construct and maintain. With the exception of a few transverse crack in one of the rails where there is a settlement of the fill, the general condition is good.

The average costs of the various types of construction including labor and equipment are compared as follows. The labor item occupies about 7% of the total cost.

I.	Cement concrete	$3.90/sq.m.	(Chinese	Currency)
II.	Cement macadam	2.30	„	„	„
III.	Concrete track	1.90	„	„	„

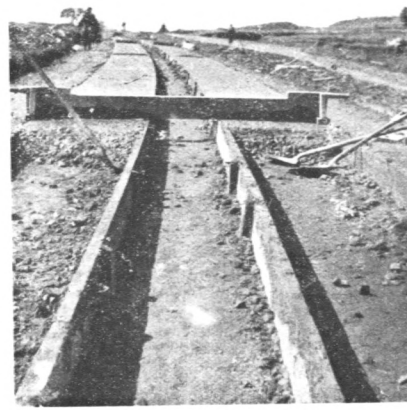


Fig. 5

The cements concrete track pavement under construction, showing the cross-section, the formwork and the implements used.

Fig. 6

The cement concrete track pavement after completion, showing the track and the "Tan-Shih" surfacing in between and on the sides of the track.

Because of these properties which are found in bamboo and its negligible cost in comparison with steel bars, it has been considered a promising material for the reinforcing of concrete. Two factors remain, however, to be investigated; i.e., the rate of decay and the effect of shrinkage upon the bond stress between the bars and the concrete. The Experimental Road will throw light upon its value as a reinforcing material for concrete pavements in the field of highway construction.

Status of Pavements. The general condition of cement concrete pavements is very good except a few initial cracks which appeared as corner cracks in two places, one longitudinal crack and one transverse crack in the whole length of 500 meters.

All the corner cracks occurred in the thickened edge types. There are two sets of them. One set occurred at the intersection of the longitudinal and transverse joints, where the slab is 13 cm. thick; and the other set appeared at a point 80 cm. from the edge of slab and developed across the corner which finally failed. The fact that both spots are on a fill seems to indicate that a thickness of 13 cm. is not strong enough for the present traffic on new embankment. The longitudinal crack appeared in one of the 2 course slabs. Insufficient thickness of the top layer seems to be the cause. The transverse crack occurred in type No. 27, which is an 18 cm. slab of 1:2:4 mix reinforced in both directions with bamboo bars.

(2) Cement Bound Macadams

The high cost of cement concrete pavements naturally leads us to the experimentation of cement bound macadams. Three methods of construction have been tried in the Experimental Road. The sandwich method of construction gives better result than either the penetration method or the dry mixture method. None of them, however, stands the traffic very well. Actual counts show that the Experimental Road carries an average traffic of 400 animals and 300 automobiles, half of which are heavily loaded trucks. Once or twice in a month there occurred also a dozen or more of steel-tired military carts and tanks of the caterpillar type.

While the sandwich method of construction in the experiment offers better service, the penetration method is more commonly practiced. Uniformity in the pentration of the macadam by the grout seems essential to prevent the development of flat pot holes. Richer mix of the grout is necessary to hold sand in mix with cement for a consistency that still would penetrate. In the experiment 1:2 mix was used; in the construction of the Chung-Shan Road at Hankow on an old macadam in 1933 1:1 mix was used.

The dry mixture method derives its name from the use of a dry mixture of cement and sand in the procedure of construction. It allows

which was pretreated with tung-oil. Two of them have dowels placed across the joint 5 cm. from the bottom of the slab spaced three in one meter. The dowels are all bamboo sticks 3 cm. in diameter and 90 cm. long. One side is embedded and the other side wrapped with oil paper as a sleeve is made free to move. More information about the properties of bamboo will be given in the paragraph on "Reinforcements".

Transverse Joints. Transverse joints are spaced 25 meters apart with construction joints at 12½-meter intervals. Butt joints and joints having a rest beam underneath the slab form the two types of construction used. Most of the joints were filled with oiled felt as in the longitudinal joints. The resilient property of the felt proved to be satisfactory.

Reinforcements. Reinforcements of bamboo bars were placed in three different ways. In thickened edge slabs they were placed one in each edge of the slab. In cases where transverse reinforcements alone were used, they were spaced 20 cm. apart. And when the slab was reinforced in both directions, longitudinal bars were placed in addition at 8 cm. spaces. The slabs are 18 cm. thick and the sections of reinforcements are 1 to 1½ cm. square in size placed 5 cm. from the bottom of the slab.

The bamboo reinforcements are made out of thick bamboo sticks by splitting the specimens into square sections. To reinforce slabs with bamboo bars is a novel practice, although it has been used in many other ways.[1] In order to ascertain the nature of the mechanical properties of bamboo, physical tests have been undertaken. In all, 220 tests were carried out for bending, shearing, elasticity, tension and compression respectively. The ultimate tensile strength of bamboo was worked out in the same way as it is for steel reinforced concrete. The mechanical properties of bamboo were found as follows:

Ultimate compressive stress	5,500	lb./sq.in.	388	kg./sq. cm.
Ultimate tensile stress	14,000[2]	„	986	„
Ultimate bending stress	13,000	„	915	„
Ultimate shearing stress	450	„	31.7	„
Modulus of Elasticity	1,660,000	„	116,900	„

(1) "Bamboo and Its Uses in China" by W. M. Porterfield; Chinese Government Bureau of Economic Information.

It is known to have been used to reinforce concrete friction piles for railway bridges. The chief object is to strengthen the pile during the handling and driving operations. The Whangpoo Conservancy Board at Shanghai has used concrete plates reinforced with bamboo for vertical bunding below water. It was also reported that in 1918, ¼ inch square split bamboos were used as part of the reinforcement for a two inch concrete wall designed as a protection for the 10 in. cork insulation of a cold storage for the International Export Company at Nanking.

(2) It should be remarked that the outer layer of the stem of bamboo has a tensile strength of at least 25,000 lb./sq. in. or 1,760 kg./sq. cm.

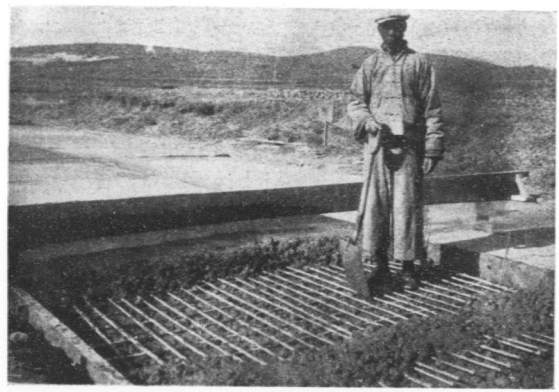


Fig. 2

Bamboo reinforcing bars of 1-1½ cm. square sections as placed in cement concrete slabs.

Fig. 1

Construction of the longitudinal joint showing the dowels across the joint and longitudinal reinforcing bars used in thickened edge sections made out of bamboo.

(1) Summary Of The Features Of Cement Concrete Pavements

Subgrade. The subgrade was prepared with special emphasis upon its uniformity. Subgrade drainage was improved by embedding bamboo pipes, 8 cm. in diameter, in the shoulders of the roads tapping at the bottom edge of the pavement and draining into side ditches.

Cross-Sections. The pavements are 5½ meters in width with a crown of 1:50 varying in other points of design. A section of uniform thickness of 18 cm. and 1:2:4 mix is constructed for comparison. Proportioning by volume was adhered to for simplicity in equipment and operation. The designs of cross section may be classified into the following three general types:

a. Single course slabs of uniform thickness. Uniform thickness of 18 cm. was constructed, both with and without longitudinal joint. Reinforcements of bamboo bars either in one direction or in both directions were placed in some of the slabs, the details being given in the paragraph on "Reinforcements". Mixes of 1:2:4 and 1:2½:5 are compared.

b. Single course slabs of thickened edges. Such sections often claim economy in the quantity of materials required and the reduction of corner cracks. Sections of 18-13-18 are tried either with or without longitudinal joint. The outside edges of the slabs are 18 cm. thick, gradually diminished to 13 cm. in a distance of 60 cm. towards the center of the pavement. Where longitudinal joint was constructed, bamboo dowels were placed across the joint, and longitudinal reinforcing bars were placed one in each edge of the slab. Further explanation about the joint is given in the paragraph on "Longitudinal joint".

The practice for city street pavements at Hankow, however, is to use 17-12-17 sections, plain, built on old macadam as foundation. Longitudinal joints of the butt type are constructed with no dowels, but the slab is also thickened near the longitudinal joint, which, of course, involves more work in the preparation of the subgrade.

c. Slabs in two courses. The slabs in 2 courses have a uniform thickness of 18 cm. in total. The top course has a denser mix of 1:2:4 and a thickness of 8 cm. The bottom course has a 1:3:6 mix and is 10 cm. thick. In this way it is expected to reduce crackings which are caused by unequal expansion due to the difference in temperature between the surface and bottom of a thick slab and the different coefficient of expansion between the denser and leaner mixes. In order to reduce the bond and friction between the contact faces of the two courses, several sheets of oil paper in one layer were spread over the surface of the bottom course.

Longitudinal Joints. Three of the types were constructed with longitudinal joints. The joints are all of butt type filled with thick felt

I. PROGRESS MADE SINCE THE CONGRESS AT WASHINGTON WITH THE USE OF CEMENT FOR THE CONSTRUCTION OF CARRIAGEWAYS

Foreword

Cement has been used in China in various forms as pavement for city streets and highways and as foundation course with bituminous wearing surfaces. Although its use for the construction of highway pavements is not justified at present in view of the light traffic, nevertheless, it has a most prospective future among the high type paving materials. A large section of the Experimental Road at Nanking, therefore, was designed with a view to studying the feasibility of the use of cement as highway pavement. It was constructed by the Bureau of Roads of the National Economic Council of the Chinese Government in 1932. Some of the engineering features were especially devised with an attempt to achieve greater economy. Hand labor was employed throughout. The road has been open to traffic for more than a year. In some respects, however, sufficient time has not elapsed to allow final conclusions. This report is concerned chiefly with the Experimental Road with occasional reference to practices elsewhere in China.

Types of Pavement

There are altogether 14 types of pavement which involve the use of cement. The total length is 800 meters divided into types of 50 or 100 meters each. According to methods of construction, they may be grouped conveniently under the following three headings:

1. *Cement Concrete Pavements.* Pavements in a single course or in 2 courses of various designs, either plain or reinforced with bamboo bars.

2. *Cement Bound Macadam.* Pavements constructed by the following three methods have been tried: (a.) the dry mixture method; (b.) the penetration method; (c.) the sandwich method.

3. *Cement Concrete Track.* Pavement with twin trails of cement concrete, the center and sides of which are paved with "Tan-Shih" (stone-pitching) pavement. The cement used is Portland cement, manufactured in this country, either by the wet or by the dry process and tested to standard specifications. Grushed stones of hard lime-stone and quartzite are used as coarse aggregates and selected river sands as fine aggregates.

(5) Where the preparation of a report is entrusted to several writers it is open to these to come to an understanding amongst themselves as to whether they desire to submit a joint report signed by all the authors or whether they prefer to divide various chapters between themselves, leaving the different authors to sign their respective sections.

In the latter case the length of the various chapters to be written by the different authors is to be determined by the authors; any difference of opinion which might arise being settled in the case of countries which have Organising Committees, by the local Organising Committe, and, in other cases, by the chief delegate representing the particular country on the International Commission. In all cases, however, the report must comply with the limits indicated in paragraph (4) above.

CONDITIONS REGARDING THE REPORTS TO BE PRESENTED AT THE SEVENTH INTERNATIONAL ROAD CONGRESS

Munich—September 1934

(1) Each country may submit not more than one report on each of the prescribed subjects but collaboration may take place between various writers on each question. Each report should so far as possible end with definite conclusions so as to facilitate the task of the Reporter-General whose duty it will be to present a summary of all the reports on a particular question at the Congress.

(2) The reports must reach the Secretary-General of the Association (1, Avenue d'Iena, Paris) before the 15th of November, 1933, this being the latest permissible date.
(Date extended to March 1 1934 by later notice.)

(3) The reports may be written in English, French or German. They should be submitted in triplicate and typewritten on one side only.

This number is necessary to enable the Secretary-General to have the reports translated and printed simultaneously in the different languages. The authors may, if they desire, furnish the translations of the reports themselves.

(4) The conditions governing each of the reports are as follows:

(a) *Length of Text.* The length of each report should not exceed 8,000 words, that is to say, about 20 pages containing 400 words each, except that the report on the Second Question which presents special features may reach a maximum of 12,000 words;

(b) *Illustrations and photographs in the Text.* The number of illustrations is limited to six, provided the space occupied by such illustrations does not exceed a total of 50 square inches;

(c) *Illustrations apart from the Text.* The number of illustrations (designs or photographs) to be printed apart from the text is limited to two. The size of such illustrations should not exceed 9″×18″ including the surround.
NOTE: It is requested that in order to ensure clear reproduction the illustrations other than photographs (e. g. plans) should be drawn on tracing paper or cloth with heavy black lines.

LIST OF REPORTERS

1st Ques.	C. H. CHANG,	Assistant Engineer, Bureau of Roads, National Economic Council, Nanking
	H. TSAI,	Designing Engineer, Hankow Municipal Government, Hankow
2nd Ques.	T. S. HSUEH,	Engineer, Public Works Department, the Municipality of Greater Shanghai
	C. H. CHANG,	Assistant Engineer, Bureau of Roads, National Economic Council, Nanking
3rd Ques.	F. C. CHOW,	Chief Engineer, Hunan Highway Administration, Changsha
	T. S. HSUEH,	Engineer, Public Works Department, the Municipality of Greater Shanghai
	C. H. O'YANG,	Engineer, Hunan Highway Administration, Changsha
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	N. M. HO,	Traffic Superintendent, Public Works Department, the Municipality of Nanking
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	Y. C. LIU,	Engineer, Public Works Department, the Municipality of Hankow
6th Ques.	C. Z. WANG,	Assistant Engineer, Bureau of Roads, National Economic Council, Nanking
	A. ZEE,	Assistant Engineer, Inter-Provincial Traffic Commission, Nanking

CONTENTS

CHINA'S REPORT

to the

SEVENTH INTERNATIONAL ROAD CONGRESS

Munich, Germany

September, 1934

Prepared under the Auspices of the Bureau of Roads
National Economic Council
Nanking, China

February, 1934

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7