LOW COST ROAD SURFACING (LCS) PROJECT

LCS WORKING PAPER No 16

CLAY BRICK PAVING INVESTIGATIONS IN VIETNAM

by

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THE LOW COST ROAD SURFACING INITIATIVE

The Low Cost Road Surfacing (LCS) initiative aims to provide documentation and international guidelines on the provision and maintenance of low cost road surfaces and basic access for rural communities in economically emerging and developing countries (EDCs). It is based on a research project funded principally by the British Department For International Development (DFID) under its Knowledge and Research (KaR) programme. The initiative is led by UK-based specialist consultants Intech Associates. Collaboration is being established with a number of organisations with interests or experience in the sector, including CSIR, TRL Ltd, ILO/ASIST Africa and Asia-Pacific, the ILO-SIDA funded Upstream Project and Ministry of Rural Development Cambodia, WSP International, Ministry of Transport Vietnam, Greater Mekong Sub-region Academic Research Network, The Institute of Technology of Cambodia, Chieng Mai University Thailand, the Committee C20 (Appropriate Development) of PIARC (World Road Association) and the International Focus Group. The LCS programme is being implemented over a 4 year period from 2001 to 2004.

The LCS programme is concerned with supporting sustainable improvements in low cost, road surfacing and basic access to support poverty reduction initiatives in rural communities. This implies the effective use of local resources, particularly human resources, locally available and alternative materials, and readily available and low cost intermediate equipment wherever possible. In the situation of scarce financial resources, it also requires the application of affordable and appropriate standards and adoption of techniques suitable for use by the indigenous private sector (particularly small domestic construction enterprises) and local communities. The application of good management practices coupled with adequate technical inputs are also encouraged.

It is intended that dissemination of the guidelines will be through electronic media as well as more traditional publication routes.

INTERNATIONAL FOCUS GROUP

TRL is currently carrying out a number of research projects on low volume sealed and unsealed roads for DFID and other donors. Intech Associates is carrying out research on low cost surfacing with a number of partners. As part of these projects, an International Focus Group (IFG) has been established. The main function of the IFG is to thoroughly examine technical, economic and social issues arising from the project work. The group will also provide a focus to improve opportunities for dissemination of project results. The IFG being developed will comprise technical experts and engineers from a number of African, Asian and other countries as well as other international experts. Participation in the IFG will provide opportunities to:

- *build regional and international partnerships*
- *exchange ideas, experiences, information and data*
- *strengthen local knowledge with new information*
- *build on existing local research*
- *promote wider acceptance of the projects themselves*

Four projects listed below, are of particular interest to the IFG. Projects 1, 2 and 4 are part of the DFID's Knowledge and Research programme, whilst Project 3, is a collaborative research project involving a number of different donors:-

Project 1: Reducing Whole Life Costs: Environmentally Optimised Design

Project 2: Minimising the Cost of Sustainable Basic Rural Road Access

Project 3: Engineering Standards for Labour-based Roads

Project 4: Low Cost Road Surfacing

Refer to: www.ifgworld.org

TRANSPORT LINKS

DFID and previous UK government administrations have a long history in funding, promoting and disseminating transport research for developing countries and countries in transition. Through the Knowledge and Research (KaR) programme, DFID supports a range of research projects addressing technical, economic, management and policy issues in transport development.

Many of the research outputs may be downloaded from:

www.transport-links.org

THIS WORKING PAPER

This document is intended to inform and provoke discussion, contributions and dissemination regarding surfacing aspects or rural roads. The LCS Project welcomes dialogue with engineers, managers, organisations, communities and individuals active or interested in the rural transport sector with the objective of the promotion of a sustainable rural access approach for EDCs.

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CLAY BRICK PAVING INVESTIGATIONS IN VIETNAM

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Abbreviations and Glossary

ADT	Average Daily Traffic
CBR	California Bearing Ratio
Cm	centimetre
CPC	Commune Peoples Council
Cong Nong	Light locally made Truck
CSIR	Council for Scientific and Industrial Research
DBST	Double Bituminous Surface Treatment
DCP	Dynamic Cone Penetrometer
DFID	Department For International Development
EDCs	Economically emerging and Developing Countries
esa	equivalent standard axles
IFG	International Focus Group
ILO	International Labour Office
ITC	Cambodia Institute of Technology
IRI	International Roughness Index
KaR	Knowledge and Research
kg	kilogram
km	kilometre
kN	kiloNewton
LCS	Low Cost Surfacing
MERLIN	**M**achine for **E**valuating **R**oughness using **L**ow-cost **In**strumentation
MoT	Ministry of Transport
mm	millimetres
m	metres
N/mm²	Newton/millimetres squared
PIARC	World Road Congress
PID	Project Implementation Department
RT1/2	Rural Transport Project 1 and 2
RTU	Rural Transport Unit
SBST	Single Bituminous Surface Treatment
SN	Structural Number
TEDI	Transport Engineering Design Incorporation
TRL Ltd	Transport Research Laboratory Limited
US$	United States Dollar
VND	Vietnamese Dong (currency)

LCS WORKING PAPER No. 16

BRICK PAVING INVESTIGATIONS IN VIETNAM

By Bach The Dung – TEDI & Tran Tien Son – RTU, PID, MoT

1 INTRODUCTION

The Government of Vietnam has been constructing rural roads throughout Vietnam to provide year-round access to communes hitherto suffering from lack of this basic infrastructure facility. Two important programmes providing these new access roads have been the Rural Transport Programme 1 (RT1) and Rural Transport Programme 2 (RT2). The latter programme will continue until 2005.

Almost all RT1 & RT2 rehabilitated road links are constructed to gravel or stone macadam pavement standard; because of the limited investment rate per kilometre provided under the programmes. The experience has been that in many provinces, these pavements have deteriorated quickly due to the particularly aggressive environment in Vietnam. Gravel roads also cause environmental pollution due to dust in the dry season (especially near markets, schools, hospitals etc.), and create a burden for local people who are principally responsible for the maintenance. At present, MoT and Donors are funding Surfacing Research to identify appropriate alternative surfacings for rural roads. Clay Brick pavement is one of the options being investigated as part of the Surfacing Research.

2 HISTORICAL CLAY BRICK USE IN VIETNAM

Burnt clay bricks have been used for centuries in Vietnam for buildings, structures and roads. Brick roads are found in many communities in various regions of Vietnam. The widespread availability of clay in the delta and lowland areas, and the accessibility to suitable fuels such as wood and coal, make this an appropriate construction material in many locations. Modern production techniques have made fundamental changes to the development as well as the quality and the cost of daily life products such as clay bricks. However, some ancient clay brick structures have already survived for thousands of years despite the challenge of time and the extreme weather experienced in Vietnam. For example, the annual rainfall in most of Vietnam exceeds 1,500mm, and typhoons bring very high intensity rainfall.

This study investigated how these structures were constructed in previous times. Until now it has been difficult to find records regarding the techniques of construction material manufacturing, construction methods, construction equipment, and mobilisation of resources etc. It is intended that the study of the past experiences could benefit the present investigations of the use of clay brick paving for rural access roads.

When visiting communes and villages in Vietnam, travellers can see that bricks are used in many structures such as temples, pagodas, tombs, irrigation canals, village roads etc. Bricks are of different sizes and different pattern reflecting their historical development and usage.

At present, all national and provincial roads are built with an asphalt concrete, macadam or cement concrete surface. However, it is not possible to apply these kinds of surfacing to many rural district and commune roads due to the high costs. Meanwhile, many villages and communes already have roads surfaced by bricks, hand packed stone and dressed stone etc. Some have existed for hundreds years and are still now under satisfactory operation. In the past there was no cement, or modern construction equipment such as stone crushers, trucks, rollers etc.

Figure 1 – Traditional coal fired brick kiln

Figure 2 – Clay brick village road

Figure 3 – Ancient Brick structures

Clay bricks have traditionally been burnt in small local kilns using coal or wood as fuel.

The skills are well established in many communities. The traditional binding materials for the joints between bricks were hydrated lime, sand, honey and salt.

The only construction equipment required was hand carts, pulleys, boats etc. for hauling the raw materials and finished products. The processes have been largely labour based with little capital investment requirements in equipment or production facilities.

For all the simplicity in the production methods, the various constructions of roads, buildings, irrigation canals, and pagodas still exist after a long passage of time.

An important consideration is whether to maintain and encourage the traditional methods, or to change to other new methods?

The study team surveyed four locations:

- Boi Khe village, Tam Hung commune, Thanh Oai district, Ha Tay province,
- Bat Trang, Gia Lam, Ha Noi ,
- Ninh Hiep, Gia Lam, Ha Noi
- Chem, Tu Liem, Ha Noi.

3 MARRIAGE PLEDGES

In the past, when a girl got married to a boy from another village, then the boy's family had to pay 500 to 1000 pieces of brick to the girl's village. This kind of traditional custom existed in many communities before 1945 but has now lapsed.

Apart from the bricks contributed by the groom's family, the village people paid for the other materials such as lime and sand and the hire of a construction team to build the section of road.

Figure 4 – This brick road section is more than 60 years old in Ninh Hiep Commune, Gia Lam District, Ha Noi.

Figure 5 – Clay brick suitable for heavy traffic

Figure 6 – Clay brick stockpiles

This was an important contribution to development of the community infra-structure.

When consulted about their views on brick paving, the communities' response was generally that brick surfaces are appropriate as they can be constructed at reasonable cost. Brick pavements are considered to be cheaper than cement concrete. They are easy to build with local skills, without requiring heavy equipment such as graders, rollers etc.. The brick paving is durable, requires little maintenance, and is anyway easy to maintain; worn broken or damaged bricks can be easily replaced. Investment can be made in small stages as resources become available.

4 MANUFACTURE OF CLAY BRICKS

Bricks are manufactured by manual methods in most provinces in Vietnam. The exception is for some provinces, where there are not sufficient clay deposits. The common method is to use coal dust as the fuel. Manufacturing technology is simple, apart from the material requirements of suitable soil composition. The technology includes crushing, mixing, casting, drying, kiln construction, shaping the coal brickettes, arranging bricks and fuel in the kiln and burning.

Many families are able to build a kiln inside their garden, and manufacture bricks for building houses. However, bricks cannot be manufactured in some locations in the Mekong delta because the clay composition of local soil is not suitable for making bricks.

Some other provinces in Mekong delta use the husk from rice for burning the brick (The husk is considered to be a waste product). Some kilns will use wood, and or rice husk.

The quality certificate of the Tunnel brick factory (fueled by coal) in Lai Chau showed the compression strength of the bricks of 7.5 N/mm^2. The strength of rice

Figure 7 – Rice Husk stockpile at small kiln

Figure 8 – Rice Husk/Wood kiln

Figure 9 – Large Scale coal fired brick factory, Lai Chau

husk-burned bricks in Dong Thap is 70daN/cm^2 = 7N/mm^2. So the achievable quality of husk-burned brick is the same as that of coal-burned bricks. The shape tollerances of the husk burnt bricks are also comparable to the large scale factory coal fuelled bricks.

Previously, when coal was not available, clay bricks were burnt by straw, rice husk, or logs in crude kilns and the resulting brick quality was sometimes not good. Bricks were soft and easily worn out by the movement and abrasion of vehicles. Some ancient brick roads built 100 years or more ago are seriously worn. For example, the brick section in front of Boi Khe pagoda built hundreds of years ago is now still being used but is worn unevenly due to variable quality of bricks. However, despite these imperfections, it is still serviceable.

Compared to modern design standards which aim to provide serviceable pavement for periods of typically 20 – 40 years, the performance of these brick surfaces is usually excellent.

Some provinces invest in new technology for making high quality bricks. Bricks are burnt inside a tunnel on a rail-based production line. (example Figure 9).

Bricks are still main and essential construction materials for building houses, schools, roads, irrigation structures etc. in many parts of Vietnam.

5 SPECIFIC ISSUES FOR CONSTRUCTION

In the communities visited for these investigations, the typical paving width for the village streets is from 1.2 – 1.5 metres.

From interviews with the community representatives familiar with the construction works and methods for the brick paving, the following information was assembled regarding the techniques used for pavements suitable for light (usually handcart, bicycle, and motorcycle) traffic:

- Grass cutting, mud removing: grass cutting was carried out within the limits of the construction width. Organic soil and mud was removed from the embankment foundation. The embankment fill was placed after removing mud and organic soil.
- Shaping the road: Pegs and string lines were used to control the shape of the final formation cross-section for the builder.
- Embankment fill: This was made from the locally available high-density clay soil, with reasonable moisture content to ensure satisfactory density when compacted. The optimum moisture content can be identified by experience: squeeze the soil and release; if the soil is smooth and not wet, then it is acceptable. Lay and compact the soil layer by layer from bottom to top. Each layer is laid 10cm thick. The fill layers will be compacted by hand with cast iron or wooden rammers of 30 - 40kg for 7 to 10 times at each spot for each layer. The later compaction must overlap 1/3 or 15 to 20cm of the area of the former compaction. The camber is formed with cross fall from 2 to 3% for pavement surface drainage. For road sections next to ponds or lakes, the shoulder should be strengthened, for example by bamboo piles, to prevent erosion.

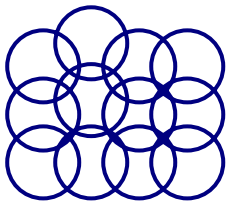


Figure 10 – Plan Layout of overlapping compaction.

- Bedding sand: When the subgrade was finished, a 2cm sand bed layer was laid with compaction. Then a layer of mortar grade 50 of 2cm thick was laid on top of the sand bed. The mortar comprised cement, lime, and sand (See the table of mortar composition). In the past sand, lime, sugar and salt were used for mortar.

Composition of mortar:

Mortar grade	Cement grade	Materials for 1m³ of mortar		
		Cement (kg)	Quick lime (kg)	Sand (m3)
50	PC-30	256	57	1.1
	PC-40	196	59	1.1
75	PC-40	275	43	1.1

Table 1 – Mortar Mixes

- Clay Brick Laying: The bricks were invariably burnt at local village kilns. These bricks were laid on edge with joints filled with mortar. The mortared joints are 1.5 to 2cm wide. The mortar was of grade 150 with the proportion of 3 sand, 1 cement. Bricks for paving should be well and uniformly burnt, solid, have single regular size, square edge, good shape and no cracks. The burning level of bricks is shown by their colour. Also when knocked together they emit a ringing sound. Bricks for paving must be clean and free from mud. The typical size of a brick is 5 x 10 x 20 cm. Bricks are laid on edge with the size of 5 x 20 cm in plan. The 10 cm side is placed vertically. The 20 cm side is placed perpendicular to the road alignment. Bricks must be laid in lines with joints staggered (stretcher bond). Brick roads can be used 10 days after construction.

If the brick roads are to be used for 4 wheel-motorised vehicles (cars, light trucks, “Cong Nong” etc.), there will be additional requirements. For example the pavement is typically constructed to a width of 3.5m or more for rural road standards. The edges of the pavement are usually strengthened with an additional layer of edge bricks. The brick surfacing is also often laid in bays of about 3 metres with mortar bedded and jointed ‘crosswalls’ dividing each bay. In some cases the bricks within in the 3 metre bays are jointed with sand only. This reduces costs significantly, however more maintenance is expected.

The subgrade may need to be improved on weaker soils to withstand the higher traffic loadings. This is an issue that will require further investigation. This is important as the rigid ‘slab’ nature of brick paving will have a better load spreading property than gravel, macadam or pen-mac paving.

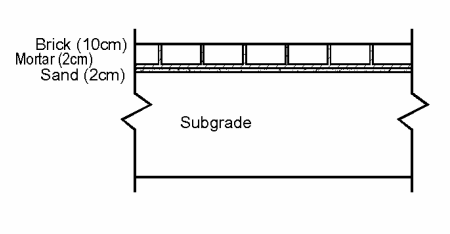


Figure 11 – Brick pavement structure

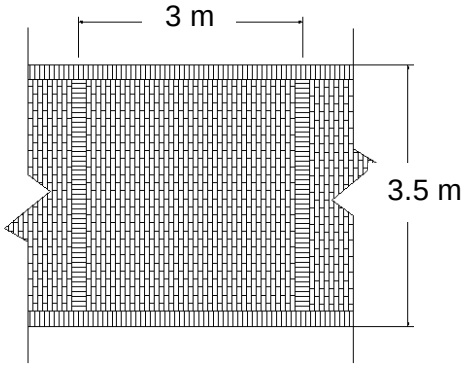


Figure 12 – Layout of brick surface

Brick surface quality and therefore durability, depends on quality of bricks, mortars, sub-grade and the skills of the labour. The wear of some ancient brick roads is uneven. It was explained by a village elder that in the past, there was no coal to burn brick. Bricks were burnt by using log fuel. Therefore brick quality was usually not as good and more variable.

6 MAINTENANCE

In general, brick surfaces do not require a lot of maintenance, unlike gravel or stone macadam surfaces. Broken or worn bricks can be replaced easily and this work can be carried out by local people using simple hand tools, used in the local building construction sector. These include hammers, chisels, hoes, spades, trowels, spirit level, hand held rammer etc. Materials like bricks, cement and sand are available locally in most provinces.

7 COSTS

Estimated typical cost for 1km of mortared brick pavement with 3.5m width is about VND 169 million, equivalent to US$ 11,262 / km.

The Table (2) below summarises the cost estimates of brick and some other pavements. The data uses 2001 prices for a typical Vietnam situation, using current cost norms.

No	Pavement	Cost per 1m² (VND)	Cost for 1km with road width 3.5m	
			Million VND	US$
1	Stone macadam 15cm	22,970	80.4	5,360
2	Brick+sand & mortar joints	32,757	114.7	7,643
3	10cm crushed stone subgrade + 10cm macadam pavement + bituminous dressing (single seal) @ 3,5kg/m².	35,181	123.1	8,209
4	Brick+mortar joints	48,265	168.9	11,262
5	8cm crushed stone layer + 16cm cement concrete pavement - grade 200	71,498	250.2	16,680

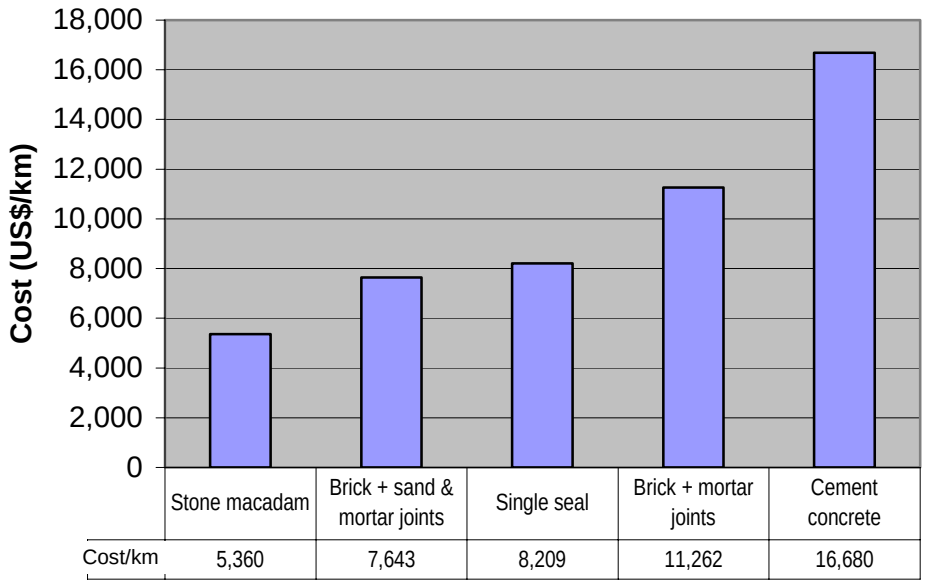
Table 2 – Cost Estimates for Various Pavement Types[1].

Note that the costs can vary considerably, depending on a number of factors, particularly the haul distance for the materials. Costs are for pavement only, and do not include earthworks, drainage and structures costs.

The above cost estimates are shown graphically in Figure 13.

1 Note: In numbers in this report ‘,’ denotes thousands and ‘.’ denotes decimal point.

Figure 13 - Example Estimated Surface Option Costs



8 ADVANTAGES AND DISADVANTAGES

Advantages:

- Suitable for the different climatic zones, where bricks are available. In Vietnam, bricks are available in most of Northern and Central provinces and in some Southern provinces. Bricks can be manufactured locally, close to the road site.
- Bricks are easy to transport without specialised vehicles. Simple vehicles can be used such as light trucks, “Cong nong”, boats, animal carts, motorbikes, boats, bicycles and even pedestrian carrier. Sand for bedding and jointing is usually available within short haul distances. Cement is available everywhere within Vietnam.
- Easy to construct using simple labour techniques. Brick paving can be constructed by small contractors or a village construction team. Construction equipment is not required, only simple hand tools are required, such as hoes, spades, trowels, spirit levels, hand held rammer etc.
- Surfaces do not cause environmental dust pollution in use, like gravel and macadam surfaces.
- The surface is easy to clean, so that there are health benefits in residential areas.
- Easy to maintain (broken bricks can be replaced easily). It can be maintained using local labour and resources. No periodic maintenance requirements like gravel and stone macadam roads. Maintenance budget requirements are within the capacity of local communities.
- Investment for brick road can be done through multiple stages. It is particularly

suitable with the annual contribution of local people.

- In terms of asset whole life costs (initial construction costs plus maintenance costs) the brick surface often has lower costs than other surfaces (gravel, stone macadam).

Disadvantages:

- Initial construction cost is higher than gravel and macadam surfaces.
- The sub-grade must be strong enough to avoid local depressions. Local depressions can lead to cracks in mortared joints and as a result of this bricks can be damaged. Weaker subgrades need to be improved or overlaid with a roadbase.
- Construction speed is slow due to labour-based construction and time for curing.
- Only suitable with non-motorised and light vehicles, unless foundations designed for heavy vehicles.
- Surface is slightly rougher than bituminous or cement road. However this should not affect vehicle operating cost for rural traffic significantly.

9 CONCLUSIONS

- Clay brick surface is a traditional surface in Vietnam. This surface had been developed helped by the traditional marriage pledges. There are some ancient brick roads providing service for hundreds of years in some villages of Vietnam.
- Bricks are available in many areas. Construction techniques are simple and can be carried out by local labour. Brick surface requires less maintenance and therefore can reduce maintenance burden to local authorities within the current very limited budgets.
- There is no official document so far providing information on the construction and maintenance of brick roads in Vietnam. Therefore it is necessary to have a study and fund for compiling such documentation.
- Currently many communities do not want problematic gravel or crushed stone macadam roads. This is due to the considerable ongoing maintenance needs and costs. They prefer to spend limited budgets on constructing higher standard and more expensive road surfaces, such as bituminous or cement concrete road. There is no consideration of appropriate surfacing in terms of local conditions, resources and utilisation purpose. This wastes the local limited resources. Some villages even spend more money to cover existing brick surface by cement concrete. Therefore it is necessary to publicise and disseminate information and knowledge about the selection of appropriate surfacing to ensure effective investment and utilisation of local limited resources.
- There is a good brick commune and village road network established in many communities, for example Ninh Hiep commune, Gia Lam district, Ha Noi. This network includes foot, bicycle, motorcycle roads and even roads for cars, and Cong Nong (Capacity about 2 tons). There are some old brick road sections, which were built more than 60 years ago. (Figure 4). In the view of Ninh Hiep CPC chairman - Mr Nguyen Trong Sam, the brick surfaces are more reasonable in cost than the cement surfaces for low-volume rural roads. It would be beneficial to organise site visits to Ninh Hiep commune for the other provinces, so that they can learn and exchange the experiences, regarding how to use brick pavement effectively.