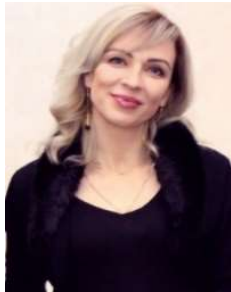


ROLLED EXTRA STIFF CONCRETE APPLICATION FOR ROAD BUILDING

ЗАСТОСУВАННЯ ТЕХНОЛОГІЇ УКОЧУВАНОВОГО НАДЖОРСТКОГО ЦЕМЕНТОБЕТОНУ ДЛЯ БУДІВНИЦТВА АВТОМОБІЛЬНИХ ДОРІГ



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Summary: Road extra stiff concrete technology review for road layers application. The technology application allows create a concrete pavement with high durability using asphalt pavers and rollers. The technology allows traffic opening in 1-3 days.

Key words: rolled extra stiff concrete, concrete pavement, high load transport, concrete layers, RCC, Roller Compacted Concrete.

Introduction: Rising of heavy-duty vehicle on roads, continuous rising of an axle load is stimulating using concrete pavements. Significant high vehicle loads occur on roads and industrial areas, in ports and approaches to them. Concrete roads application with slip form technology needs investments. Concrete roads building slip form technology stipulates traffic interruption for significant time until the concrete achieve a strength, which enough for traffic opening. The problem is actual because of agricultural heavy goods transportation rising volume from fields over secondary roads to elevators and ports, because of rising of intensity, using of modern heavy-duty vehicle and continual searching concrete roads building reduction of prices. For solving the concrete roads building problem is required a technology, which allows to get a concrete pavement and open a traffic in 1-3 days (much faster than for concrete pavements made of concrete mix with Abrams cone characteristic 1-3 cm and traffic opening not earlier 7-14 days), steady to heavy loads, environment influences, safe and economical. The task is required careful approach to concrete components, mix design and right use of rolled extra stiff concrete during road layers design.

Materials and Methods: In Soviet Union a concrete mix, which applying with asphalt pavers and compacting with rollers began using in 1984-1985 years for asphalt base layers application. Maximum class of the concrete is B10. At the same time modern concrete roads pavements strength is B30 – B35. Today coarse aggregate – sand mix, strengthened with cement wide using for concrete and asphalt road base

applications. Also, lean concrete is applied over city streets and roads with next overlay application with asphalt or other thin bituminous layer. Wherein the strength class of the concrete is not more B15 [1]. The technology of lean concrete applied by asphalt pavers is a type of roller compacted concrete but just because there used the same concrete components and the concrete mixed on concrete mix plant. As top layer of roads the roller compacted concrete not be used in Ukraine.



Figure 1 – Rolled extra stiff concrete pavement application with an asphalt paver with edge shaping
Рисунок 1 – Влаштування покриття з укочуваного наджорсткого цементобетону з формуванням кромки асфальтоукладальником

Using of roller compacted concrete for areas and roads covering started in 1930s in Sweden. In the USA first roller compacted concrete application was in Yakima airport, Washington in the beginning of 1940s. In the airport a runway was built. But the biggest development the roller compacted technology got in Canada in 1970s [5] on log sorting areas. The main requirements were quick pavement application for log trucks and loader work. At the same time there weren't any requirements for joints and smoothness. In 1980s US Army Engineer Corps was conducting big roller compacted concrete testing for freeze-thaw and natural conditions durability. The first big project was parking area for heavy military armor made in Ford Hood, Texas [6]. Reports about the testing gave "green light" for using the concrete in civil road and area building. In 1990s a road equipment industry started paver production with heavy vibrating plate and rollers which allow compaction of very stiff concrete mixes. Rising road and areas pavement load gave impulse for searching the pavement, resistant to big loads and at the same time with economical advantages. Roller compacted concrete RCC became an answer for the question.

In 1990s in the USA were made only 22 projects (418063 m²) with roller compacted concrete application [6]. In first decade (2000-2010 years) there were already 70 projects (7,4 million m²). Generally, there were industrial, military, sea ports projects. In the beginning or second decade roller compacted concrete got new scope of application: bike roads, local roads, commercial parking areas, oil and gas production. Also continuing using it in industrial and military projects. From 2011 till 2016 applied 8,4 million m² of roller compacted concrete pavements in the USA [8]. Dense structure of roller compacted concrete allows to reduce cement content in the mix without losing strength and workability. Boarder requirements to mix characteristics allow using local materials and residuals.

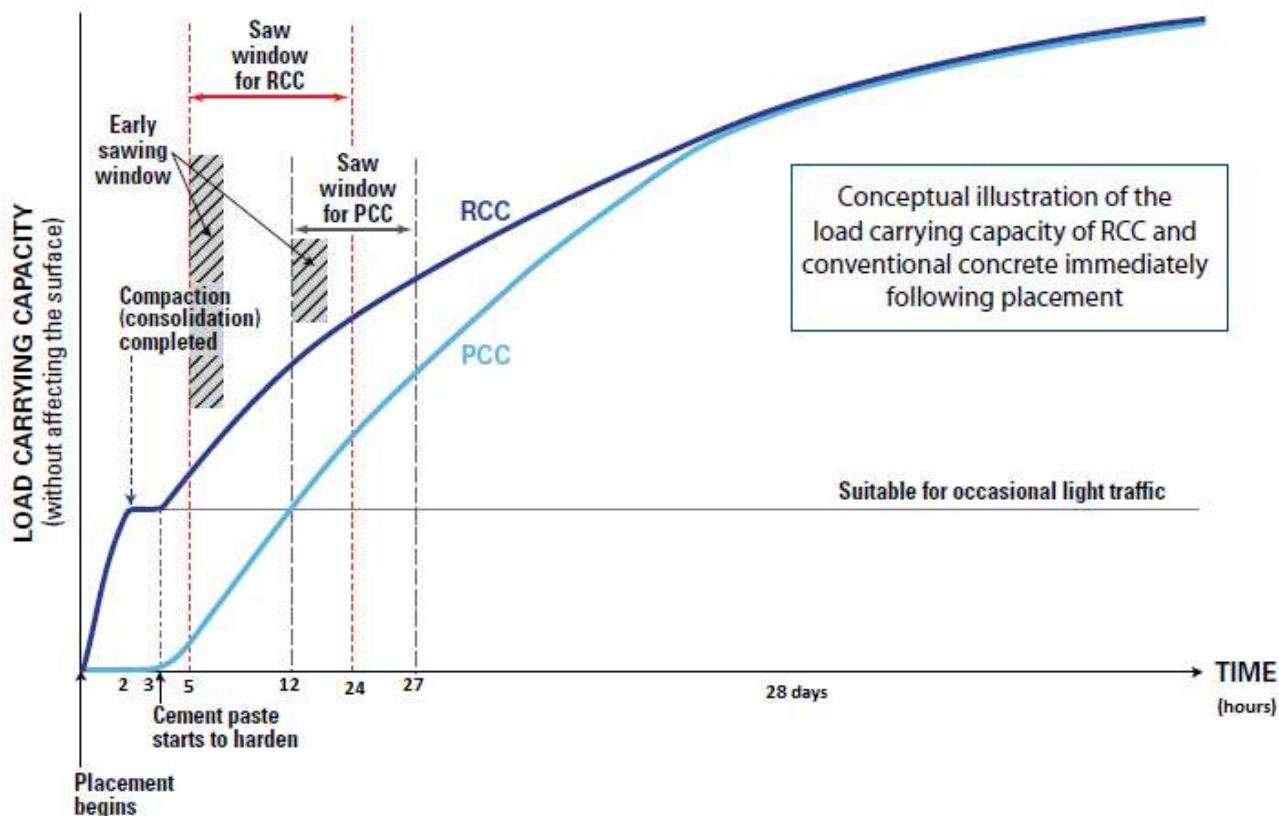


Figure 2 – Comparison in time in pavement possibility of load application for roller compacted and convenient concrete

Рисунок 2 – Порівняння у часі можливості сприйняття навантаження покриттям з укочуваного та звичайного цементобетону

Goal: World experience of road compacted concrete application review and definition of criteria and tools for using it in civil building projects in Ukraine.

Results and Discussion:

According to ACI (American Concrete Institute, USA) terminology, roller compacted concrete is defined as “concrete compacted by roller compaction that, in its unhardened state, will support a roller while being compacted”. Features of roller compacted concrete application technology based on boarder concept, which differ from convenient concrete. Roller compacted concrete durability and strength based on features of mix design, which requires only enough mortar to fill a space between aggregates.

Roller compacted concrete is a result of searching the way of make simpler existed concrete pavement technologies, searching methods of road building without bituminous materials, effort to use local materials and residuals.

Technology of road compacted concrete mix production allows to use mixing units with high productivity for support asphalt paver workability. It allows to set a high pace of concrete mix application, cutting project time and equipment operating costs. For setting necessary asphalt paver work pace on huge projects in the USA recommended using a mixing plant with 250 ton per hour productivity. According to the productivity an application speed is high. Together with early strength gain and wider window joints cut possibility give an allowance to earlier open road traffic.

Delivery, application and compaction of road compacted concrete mix are made with wide spread equipment: haul trucks, asphalt pavers, rollers. Possibility of using high volume trucks help support a pace of application. Modern asphalt pavers help to achieve 90 – 98 % of compaction, create necessary slopes and escape concrete mix segregation. Compaction with different type and mass rollers give a smoothness to the surface and make the finish surface compaction.



Figure 3 – Roller compacted concrete application
Рисунок 3 – Влаштування покриття з укоцovanого цементобетону

Low cement content in roller compacted concrete allows to make joints after bigger distance. When a project doesn't have any requirements to smoothness and to comfortable driving of high load and technological transport, during rolling compacted concrete pavement application joint don't saw.

Pavements with roller compacted concrete apply more often with 20 cm thickness in one layer. When necessary to apply bigger thickness, the application occurs in two layers. Semi-dry concrete mix consistence allows 2 subsequent layers.

Type of roller compacted concrete pavement finishing depends on requirements to driving comfort, traffic speed, available equipment and type of project. Modern approaches to a mix design and modern equipment allow getting good quality surface without additional treatment. For giving smoothness to the applied pavement should make additional operations. First variant is a grinding: align profile of applied pavement and give necessary roughness. Second variant is applying addition layer of bituminous material: help to align surface and work like wear layer. Third variant is a treatment with trowel machine and giving roughness with a special rake.

The main advantages of the technology are cost saving, fast traffic opening, using local Ukrainian materials and available equipment for application and compaction. The main disadvantage is smoothness of an applied pavement, but world experience allows foreseeing a solution of the problem.

And the end we get a concrete pavement without reinforcement, which cares high loads and it is durable to atmospheric influence and can be opened to traffic in few days.

Specialists from Department of Road Building and Maintenance of Kharkiv National auto-road University and building company Fortis Group developed regulatory document – Technical conditions. Concrete mixes and concrete extra stiff rolled [12].

Main objects where roller compacted concrete can be used are roads, logistic facilities, ports, parking for heavy duty, industrial roads, storage facilities etc.

Author has made laboratory researches for local roller compacted concrete components (cement, aggregate, sand). Author has made a roller compacted concrete mix design and made samples for strength test.

Conclusions and Recommendations:

1. Concrete pavements showed their effectiveness on high loaded roads and parking lots. Disadvantages of concrete road building technology are low construction speed and necessity in high cost equipment. The answer for this can be roller compacted concrete technology.
2. For 90 years from the beginning of roller compacted concrete utilization it go through few researches and goal application stages. There are in the world much information about design, construction and references.
3. Cost rising for bitumen in Ukraine stimulates the use of cementitious layers for road building.
4. Using local materials gives significant economical effect.

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Анотація: Огляд технології наджорсткого уочуваного цементобетону для влаштування шарів дорожнього одягу. Застосування цієї технології дозволяє виконати влаштування цементобетонного покриття з високими експлуатаційними характеристиками із застосуванням асфальтоукладальників і котків та можливістю відкриття руху по влаштованому цементобетонному покриттю через 1-3 доби.

Ключові слова: уочуваний наджорсткий цементобетон, цементобетонне покриття, великоваговий транспорт, шари дорожнього одягу з цементобетону, RCC, Roller Compacted Concrete.

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