MINISTRY OF TRANSPORT REPUBLIC OF UZBEKISTAN

MINISTRY OF HIGHER AND SECONDARY-SPECIALIZED EDUCATION

TASHKENT INSTITUTE OF DESIGN, CONSTRUCTION AND MAINTENANCE OF AUTOMOTIVE ROADS

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Increasing the strength value of crushed aggregate-sand mixture strengthened with cement for automobile road bases.

5A341401 Design and construction of automobile roads

Dissertation

On competition of Master degree

Scientific supervisor

PhD. Amirov T.J.

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MINISTRY OF HIGHER AND SECONDARY-SPECIALIZED EDUCATION

TASHKENT INSTITUTE OF DESIGN, CONSTRUCTION AND MAINTENANCE OF AUTOMOTIVE ROADS

Faculty: Masters department

Chair: "Construction and maintenance of automobile roads"

Specialty: 5A341401 Design and construction of automobile roads

Master student: U.G. Yusupaliyev 524-17 group

Research instructor: (Ph.D) T.J.Amirov

Theme: Increasing the strength value of crushed aggregate-sand mixture strengthened with cement for automobile road bases.

ANNOTATION OF MASTER'S DISSERTATION

The relevance of the theme: at present, the crushed aggregate-sand mixture strengthened with cement or Cement Treated Base is widely used in construction of national highways and other international projects in Uzbekistan. Increasing the strength value of Cement Treated Base is one of the urgent tasks in modern road construction.

Aim of the work: development of recommendations for supplementing the requirements specified in the normative documents for the strength value of Cement Treated Base.

Research objectives:

- Study of construction methods of Cement Treated Base;

- Determine the relationship between the compressive strength and flexural strength values of Cement Treated Base;

- Increasing the strength value by adding optimal amount of crushed aggregate to the local borrow material;

- Development of recommendations on adjustment of payment based on the strength results and thickness of a layer.

Object and subject of the research:

- 116-190 km section of the highway A-373 Tashkent-Osh was selected as the object of the research.
- Cement Treated Base strength values (compressive and flexural strength) are the subject of the research.

Structure and volume of the dissertation: this thesis consists of introduction part, three chapters, summary and the list of publications used. The first chapter describes the methods of construction of Cement Treated Base in Uzbekistan and other countries. The second part describes the laboratory tests conducted on Cement Treated Base. The third chapter provides recommendations for supplementing the requirements in the normative documents for Cement Treated Base.

The scientific novelty of the research: determine the relationship between strength values of Cement Treated Base and develop recommendations for their application.

Scientific and practical significance of the research results: determine the relationship between strength values of Cement Treated Base with subsequent development of methods to prevent excessive cement consumption.

Principal results of the work: the relationship between the strength value of Cement Treated Base and the durability of the stretching resistance were determined and recommendations were made for amendments and additions to the relevant regulatory documents.

Conclusion and suggestion of work: the relationship between the compressive and flexural strength values of Cement Treated Base for automobile roads was determined and recommendations were developed for supplementing the national regulatory documents. The recommendations for supplementing the national regulations were developed based on the study of foreign experience and normative documents.

Research instructor: Ph.D. T.J.Amirov

Master student: U.G.Yusupaliyev

ЎЗБЕКИСТОН РЕСПУБЛИКАСИ ТРАНСПОРТ ВАЗИРЛИГИ

ЎЗБЕКИСТОН РЕСПУБЛИКАСИ ОЛИЙ ВА ЎРТА МАХСУС ТАЪЛИМ ВАЗИРЛИГИ

ТОШКЕНТ АВТОМОБИЛЬ ЙЎЛЛАРИ ЛОЙИҲАЛАШ, ҚУРИШ ВА ЭКСПЛУАТАЦИЯСИ ИНСТИТУ

Факултет: Магистратура бўлими

Кафедра:“Автомобиль йўлларини қуриш ва эксплуатация қилиш”

Мутахассислиги: 5А341401 Автомобиль йўлларини лойиҳалаш ва қуриш

Магистратура талабаси: 524-17 У.Ғ.Юсупалиев

Илмий раҳбар:(PhD) Т.Ж.Амиров

Мавзу:Автомобиль йўллари асоси учун цемент билан ишлов берилган чақиқтош-қум қоришмаларининг мустаҳкамлик кўрсаткичларини ошириш.

МАГИСТРЛИК ДИССЕРТАЦИЯСИ АННОТАЦИЯСИ

1. **Мавзунинг долзарблиги:**

Бугунги кунда Ўзбекистон миллий автомагистралини қуришда ва бошқа халқаро тендерлар асосида қурилаётган автомобиль йўлларида цемент билан ишлов берилган чақиқтош-қум қоришмалари ишлатилмоқда. Цемент билан ишлов берилган чақиқтош-қум қоришмаларининг мустаҳкамлик кўрсаткичларини ошириш долзарб вазифалардан ҳисобланади.

2. **Тадқиқотнинг мақсади:**

Ўзбекистон шароитида маҳаллий материаллар асосида таёрланган цемент билан ишлов берилган чақиқтош-қум қоришмаларининг мустаҳкамлик кўрсаткичлари учун норматив хужжатларда белгиланган талабларни мувофиқлаштириш мақсадида тавсиялар ишлаб чиқиш.

3. **Тадқиқотнинг вазифалари:**

- мавжуд миллий ва хорижий давлатларнинг цемент билан ишлов берилган чақиқтош-қум қоришмаларини таёрлаш ва қуриш услубларини ўрганиш;

- цемент билан ишлов берилган чақиқтош-қум қоришмаларини сиқилишдаги ва эгилишдаги чўзилишга мустаҳкамлиги орасидаги боғлиқликни аниқлаш.
- маҳаллий материалларга оптимал миқдорда чақиқтош қўшиб қоришмаларнинг мустаҳкамлик кўрсаткичларини ошириш.
- цемент билан ишлов берилган чақиқтош-қум қоришмаларниталаб қилинадидиган мустаҳкамлиги ва қалинлигини чекинишларга асосан нархларни мослашга тавсиялар ишлаб чиқиш.

4. Тадқиқотнинг обекти ва предмети:

Тадқиқотнинг обекти сифатида А-373 Тошкент-Ўш автомобиль йўлининг 116-190 км бўлаги олинди.

Тадқиқот предмети сифатида цемент билан ишлов берилган чақиқтош-қум қоришмаларини мустаҳкамлик кўрсаткичлари (сиқилишдаги ва эгилишдаги чўзилишга мустаҳкамлиги) олинди.

5. Тадқиқотнинг услубияти ва усуллари:

Бажарилган магистирлик иши кириш қисми, 3 та боб ҳамда хулоса ва фойдаланилган адабиётлар рўйхатидан иборат. Биринчи бобда мавжуд миллий ва хорижий давлатларнинг цемент билан ишлов берилган чақиқтош-қум қоришмаларини қуриш услублари ўрганиб чиқилган. Иккинчи бобда цемент билан ишлов берилган чақиқтош-қум қоришмаларининг мустаҳкамликларини аниқлаш бўйича лаборатория синовлари олиб борилган. Учинчи бобда цемент билан ишлов берилган чақиқтош-қум қоришмаларининг мустаҳкамлик кўрсаткичлари учун норматив хужжатларда белгиланган талабларни мувофиқлаштириш учун тавсиялар ишлаб чиқилган.

6. Тадқиқот натижаларининг илмий жиҳатдан янгилик даражаси:

- цемент билан ишлов берилган чақиқтош-қум қоришмаларини сиқилишдаги ва эгилишдаги чўзилишга мустаҳкамлиги орасидаги боғлиқлик аниқланиб ва уларни қўллашга тавсиялар ишлаб чиқилди.

7. Тадқиқот натижаларининг амалий ахамияти ва тадбиқи:

- цемент билан ишлов берилган чақиқтош-қум қоришмаларини сиқилишдаги мустаҳкамлиги ва эгилишдаги чўзилишга мустаҳкамлиги орасидаги боғлиқлик аниқланиб ортикча цемент сарфини олдини олади.

8. Бажарилган ишнинг асосий натижалари:

Цемент билан ишлов берилган чақиқтош-қум қоришмаларини сиқилишдаги мустаҳкамлиги ва эгилишдаги чўзилишга мустаҳкамлиги орасидаги боғлиқлик аниқланди ва норматив ҳужжатларга қўшимча ва ўзгартиришлар киритишга тавсиялар ишлаб чиқилди.

9. Хулоса ва таклифларнинг қисқача умумлаштирилган ифодаси:

Автомобиль йўллари асоси учун ишлатиладиган цемент билан ишлов берилган чақиқтош-қум қоришмаларини сиқилишдаги мустаҳкамлиги ва эгилишдаги чўзилишга мустаҳкамлиги орасидаги боғлиқлик аниқланди ва норматив ҳужжатларга қўшимча ва ўзгартиришлар киритишга тавсиялар ишлаб чиқилди. Миллий норматив ҳужаттлардаги кўрсатиб ўтилмаган ва белгиланмаган муаммоли вазиятларга сабаб бўлаётган регламентлар аниқлаб олинди. Ушбу регламентларни хориж норматив ҳужжатларидан ўрганилди ва миллий норматив хужжатларга киритиш бўйича тавсиялар ишлаб чиқилди.

Илмий раҳбар: PhD. Т.Ж. Амиров

Магистратура талабаси: У.Ғ.Юсупалиев

INTRODUCTION

The Republic of Uzbekistan is located on the crossroads of the Central Asian region, which creates favorable conditions for the development of regional cooperation and for its participation in both regional and transnational projects to develop transport corridors. It should be observed here that Uzbekistan is one of the countries that boast extensive networks of roads. Their total length in the Republic comes to 183,700 kilometers, of which roads for general use make up 42,600 km, city streets – 17,800 km and inter-farm roads – 58,600 km. In the course of large-scale reforms carried out in the country in the last few years, special attention was devoted to the construction of new roads and bridges and the refurbishment of existing ones, as well as to the improvement of road infrastructural facilities. Highways that form the Uzbek National Arterial Road have been repaired and reconstructed. By the end of 2015, its total length has reached 2,306 km, of which 1,410 km are subject to reconstruction and 896 km will be transferred from the 10-ton axle-load standard to a higher 13-ton one. What's more, it is planned to undertake a major reconstruction of a 1,008-km section of Highways in the direction of Beineu – Kungrad – Bukhara – Navoi – Samarkand – Tashkent – Andijan and a 100-km section of the Tashkent – Osh on the Kamchik-Pass. Construction of Highways has always been regarded as one of the industry's priority directions. With a view to improving the quality of Highways that constitute the Uzbek National Arterial Road and bringing it closer to international standards, a big effort is now underway to attract money funds from international crediting organizations. A number of credit agreements have already been signed between the government of the Republic of Uzbekistan and international financial institutions. It is worth noting in this connection that the total amount of credit lines allotted to the country under these agreements exceeds the US $1.2 billion. All these funds will be directed towards the costs of construction of 586 kilometers of roads, of which 379 kilometers will have the cement-concrete surfacing. The cement-concrete type of surfacing, from an economic standpoint, prolongs the service life period up to 25-30 years, compared to the established 12-15-year period. At the same time, the maintenance expenditures of Highways with the cement-concrete surfacing are two times cheaper than those for Highways with the asphalt-concrete surfacing. Within the framework of the State Investment Programs of the Republic of Uzbekistan and in compliance with the Presidential Resolutions, between 2008 and 2013 the Republican Road Foundation has built and put into service 181 kilometers of Highways with the cement-concrete surfacing, with the help of credits to the tune of US $232.5 million received from the Asian Development Bank (ADB). For the time being, the construction of Highways is underway on the territory of Surkhandarya province (100 km), Kashkadarya province (35 km), Namangan and Tashkent provinces (on the Kamchik Pass) (58 km). These construction projects are realized with the participation of foreign companies such as Akkord Industry Corp., EVRASCON (Azerbaijan), POSCO Engineering & Construction Co. (Korea), etc. Apart from the Highways that are part of transport corridors and roads of republican sub ordinance, serious measures are afoot to develop regional Highways for local use. To implement such projects, the Republic of Uzbekistan is negotiating with the World Bank to receive a US $200 million credit line on favorable terms, which will be used to finance the reconstruction of 395 kilometers of Highways (in Tashkent province – 90 km, Andijan province – 106 km, Namangan province – 155 km and Fergana province – 44 km). Let it be pointed out in the conclusion that the creation of modern road-transport infrastructure in Uzbekistan will afford a wide range of potentialities for the implementation of structural reforms and technological renovation of the national economy, with thousands of new jobs created during the process for the country's younger generation. Projects realized by the Republican Road Foundation with the participation of international financial institutions (table 1.1).

Table 1.1

Projects implemented with the participation of international financial institutions

№	Name of Road	Number of Road	Section of Road	Location
1.	Guzar-Bukhara-Nukus-Beineu	A-380	km 876~ km 916 km 490~km 581	Khorezm province
2	Guzar-Bukhara-Nukus-Beineu	A-380	km 440~ km 490	Khorezm province
			km 355~km 440	Bukhara province
			km 315~km 355	
3	Tashkent-Osh	A-373	km 116~ km 123	Tashkent province
			km 136~ km 144	
			km 144~ km 173	Namangan province
			km 176 ~ km 190	
4	Pungon-Namangan	4P112	km 0~ km 75	Namangan province
5	Tashkent-Termez	M-39	km 1330~ km 1395	Surkhandarya province
			km 1400~ km1410	
			km 1426~ km 1451	
6	Guzar-Chim-Kukdala	4P87	km 38~ km 73	Kashkadarya province

As a key transit country for trade within the region and with the rest of Eurasia, Uzbekistan is a member country of the CAREC program, which aims to improve regional connectivity and cut transport costs. 4 CAREC's action plan envisages six CAREC corridors connecting the region's key economic hubs to each other, and to other Eurasian and global markets. Two corridors cross Uzbekistan, including Corridor 2, which connects the Caucasus and

Mediterranean to East Asia; and Corridor 6, which connects Europe and the Russian Federation to the Middle East and South Asia.

Uzbekistan has developed a road sector policy framework to improve governance, accountability, sustainability, seamless transport logistics, and greater private participation. Several policy and institutional reforms have been carried out since 2003, including separating planning and programming of road works from road construction and maintenance; promoting competitive bidding for all road construction works; establishing an external quality control mechanism; engaging road design engineers through competitive selection for low-class roads; and establishing a state-owned road equipment pool company to lease equipment to all contractors.

Regional Roads Development Project with the World Bank.

The objectives of the Regional Roads Development Project for Uzbekistan are to reduce road user costs on the project roads and develop a sustainable investment program for regional road asset management. There are three components to the project, the first component being the Rehabilitation of Regional Roads. This component will improve about 300 km of priority regional roads in Tashkent, Ferghana, Andijan, and Namangan. Specifically, the component will finance the rehabilitation works of existing regional roads, including structure renewal as well as the rehabilitation of ancillary road connections (i.e. crossroads, access roads, drainage systems). This component will also support the integration of road safety considerations into the design of the project's road sections. US$28.5 million contingency is added to this component and embedded in the financing of the project to cover for contingencies and volume of works. The second component is the road sector institutional strengthening. This component will finance priority road sector institutional strengthening activities, including Road asset management capacity review; Support to develop regional roads rehabilitation programs; Support to the road construction industry; capacity strengthening of the Republican Road

Fund (RRF); and Road sector governance and capacity review. Finally, the third component is project management.

Roads Development Project with the Asia Development Bank.

ADB has been Uzbekistan's lead development partner in the transport sector since 1998. The Accelerated Development Program focuses on the development of strategic corridors, including CAREC corridors, which are important for international trade and regional connectivity. A total of 1,625 kilometers of these corridors will be reconstructed and improved under the investment program. The total cost of the Accelerated Development Program is estimated at $3 billion, of which $1.6 billion will be invested for the reconstruction of the Uzbek National Highway: Beynau–Kungrad–Bukhara–Navoi–Samarkand–Tashkent–Andijan, which includes both the A380 and the A373.

As mentioned-above, Uzbekistan is performing many road constructions works based on international biddings. At the same time, many large international construction companies are working in Uzbekistan. This calls for a revision of our national standards and their adaptation to international standards. In addition, modification of requirements of technical specifications (national standards).

Pavements with Cement Treatment Base will be much stronger and more rigid than an unstabilized, granular base. Cement Treatment Base thicknesses are less than those required for granular bases carrying the same traffic. It can distribute loads over a wider area, reducing the stresses on the subgrade and acting as the load-carrying element of flexible pavement or a sub-base for concrete.

It's slab-like characteristics and beam strength are unmatched by granular bases that can fail when an aggregate interlock is lost. This happens when wet subgrade soil is forced up into the base by traffic loads. Hard, rigid Cement Treatment Base is practically impervious. It resists cyclic freezing, rain, and spring-weather damage. Cement Treatment Base continues to gain strength with age even under traffic. This reserve strength accounts in part for Cement Treatment Base's excellent performance.

The versatility of cement is critical to the success in this pavement solution because site conditions and soil types (from gravel to clays) can easily change during or between projects and cement acts as a “universal stabilizer.”

Cement Treatment Base is suitable as a base (for asphalt pavements) or sub-base (for concrete pavements) of:

- Mainline highways
- High-volume streets and local roads
- Residential streets
- Heavy industrial/intermodal/military facilities
-Airport runways, taxiways, and aprons
- Parking lots

Solutions Provided:

- Lower cost through the use of local or marginal aggregates
- Eliminates subgrade infiltration into base
- Fast construction
- Reduced moisture susceptibility
-Reduces work stoppages due to rain (open base sheds water)
-Frost-resistant
-Spans weak subgrades

The relevance of theme: Research and experience have shown that, with a small addition of Portland cement, many inferior aggregates can be used to construct a strong, durable pavement layer called cement treated base (CTB). Nowadays, Cement Treatment Base (by GOST 23558) is used almost for whole Uzbek National Highway (Beynau–Kungrad–Bukhara–Navoi–Samarkand–Tashkent–Andijan). Increasing the strength value of Cement Treated Base is one of the urgent tasks in modern road construction.

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Aim of the work: development of recommendations for supplementing the requirements specified in the normative documents for the strength value of Cement Treated Base.

Research objectives:

- Study of construction methods of Cement Treated Base;
- Determine the relationship between the compressive strength and flexural strength values of Cement Treated Base;
- Increasing the strength value by adding optimal amount of crushed aggregate to the local borrow material;
- Development of recommendations on adjustment of payment based on the strength results and thickness of a layer.

The object of study: 116-190 km section of the highway A-373 Tashkent-Osh (Cement Concrete Pavement) was selected as the object of the research.

The subject of the study: Cement Treated Base strength values (compressive and flexural strength) are the subject of the research

Methods of research: the work was carried out using complex research methods, including information analysis and with the use of laboratory equipment.

The scientific novelty of the research: determine the relationship between strength values of Cement Treated Base and develop recommendations for their application.

The practical value of the research is determine the relationship between strength values of Cement Treated Base with subsequent development of methods to prevent excessive cement consumption.

Principal results of the work: the relationship between the strength value of Cement Treated Base and the durability of the stretching resistance were determined and recommendations were made for amendments and additions to the relevant regulatory documents.

CAPTER I. ANALYSIS OF CEMENT TREATMENT BASE CONSTRUCTION

1.1 Existing methods of Cement Treatment Base (CTB) construction

Cement Treatment Base (CTB) is a mixture of pulverized material and measured amounts of Portland cement and water, compacted to high density. As the cement hydrates, the mixture becomes a hard, durable paving material. Only three basic ingredients are needed for CTB: material, Portland cement, and water. The material in CTB can be a wide variety of materials. Either in-place or borrow material can be used. Old granular-base roads, with or without their bituminous surfaces, can be recycled to make CTB.

CTB is sometimes called a cement-stabilized-aggregate base. Regardless of what it is called, the principles governing its composition and construction are the same.

While the concept of stabilizing soils and aggregates for pavement purposes has been around for more than a century, engineered CTB was first used in 1935 to improve the roadbed for State Highway 41 near Johnsonville, South Carolina. Today, thousands of miles of CTB pavements in every state in the United States and in all the Canadian provinces are providing good service at low maintenance costs.

CTB is widely used as a pavement base for highways, roads, streets, parking areas, airports, industrial facilities, and mate- rails handling and storage areas. The structural properties of CTB depend on the soil/aggregate material, quantity of cement, curing conditions, and age [1].

The advantages of CTB are many:

• CTB provides a stiffer and stronger base than an unbound granular base. A stiffer base reduces deflections due to traffic loads, which results in lower strains in the asphalt surface. This delays the onset of surface distress, such as fatigue cracking, and extends pavement life (see Figure 1.1).

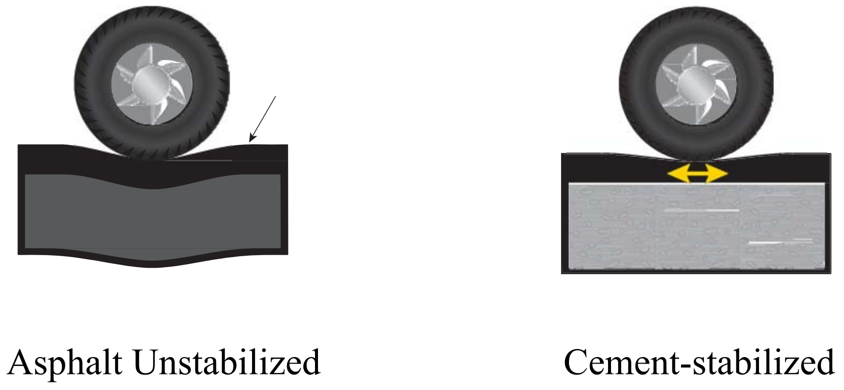


Figure 1.1. Unstabilized bases have high deflection due to low stiffness, which results in high surface strains and eventual fatigue cracking. The higher stiffness provided by cement-stabilized bases produces lower deflections, resulting in lower surface strains and longer pavement life [1].

• CTB thicknesses are less than those required for granular bases carrying the same traffic because the loads are distributed over a large area. The strong uniform support provided by CTB results in reduced stresses applied to the subgrade. A thinner cement- stabilized section can reduce subgrade stresses more than a thicker layer of untreated aggregate base. Subgrade failures, potholes, and road roughness are thus reduced. CTB's slab-like characteristics and beam strength are unmatched by granular bases that can fail when an interlock is lost. Figure 2 is a core of completed CTB showing the tightly bound soil/aggregate.

• A wide variety of in-situ soils and manufactured aggregates can be used for CTB. This eliminates the need to haul in expensive select granular aggregates.

• The construction operation progresses quickly with little disruption to the traveling public. It can be accomplished while still maintaining traffic.

• Rutting is reduced in a CTB pavement. Loads from channelized traffic will displace unbound granular material beneath flexible surface pavements.

• Moisture intrusion can destroy unstabilized pavement bases, but not when cement is used to bind the base. CTB pavements form a moisture-resistant base that keeps water out and maintains higher levels of strength, even when saturated, thus reducing the potential for pumping of subgrade soils (see Figure 1.2 and 1.3).

• CTB provides a durable, long-lasting base in all types of climates. As an engineered material it is designed to resist damage caused by cycles of wetting and drying and freezing and thawing.

• Similar to concrete, CTB continues to gain strength with age. This is especially important when considering that many pavements experience greater traffic loads and volume throughout their service life. This reserve strength accounts in part for CTB's fine performance.

Figure 1.2. Pavement core proves strength of CTB

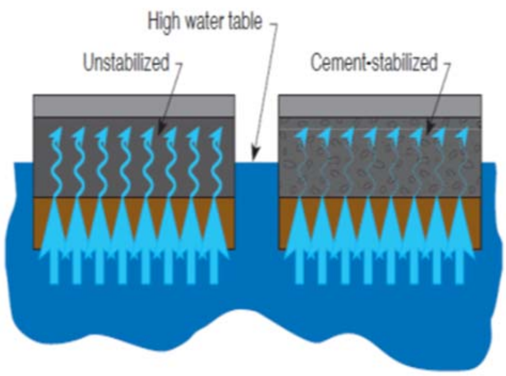


Figure 1.3. Moisture can infiltrate unstabilized bases through high water tables or capillary action causing softening, lower strength, and reduced modulus.

In CTB construction, the objective is to thoroughly mix a soil/aggregate material with the correct quantity of portland cement and enough water to permit maximum compaction. The resulting CTB must be adequately cured to provide the necessary moisture needed for cement hydration to fully harden the CTB mixture.

The fundamental control factors for quality CTB are:

1. Proper cement content
2. Adequate moisture content
3. Thorough mixing

4. Adequate compaction

5. Proper curing

The construction steps are:

Preparation

- Checking and calibration of equipment
- Correcting any soft subgrade areas
- Shaping the area to proper crown and grade

Mixed-in-Place Processing

- Spreading portland cement and mix
- Applying water and mix
- Compacting
- Finishing
- Curing

Central Plant Processing

- Mixing soil/aggregate material, cement, and water in a central plant
- Hauling and spreading
- Compacting
- Finishing
- Curing

The area to be paved must be shaped to proper crown and grade. Proper compaction is one of the fundamental requirements for CTB construction. If the subgrade is soft and cannot support the compaction equipment, adequate density will not be obtained. Therefore, soft areas should be located and made stable before CTB material is mixed or placed.

Soil/aggregate, cement, and water can be mixed in a central mixing plant, or mixed in place using traveling mixing machines. The mixing methods include:

1. Single-shaft in-place mixing equipment
2. Central mixing plants

- Continuous-flow-type pugmill

• Batch-type pugmill
• Rotary-drum mixer

Mixed-In-Place Method

Soil/aggregate in required quantity should be distributed on an accurately graded, well-compacted subgrade in an even layer or in a uniform windrow, depending upon the type of mixing equipment to be used. For maximum efficiency, the day's work should be broken down into several adjacent sections rather than one or two long sections. Bulk cement is normally hauled to the job site in bulk transport trucks. Cement is then transferred to job cement storage trucks, which are usually enclosed or fitted with canvas covers. Cement is transferred into the cement storage trucks pneumatically by a screw or belt conveyor. Prior to cement spreading, truckloads of cement are weighed on portable platform scales or at a nearby scale. A mechanical cement spreader is attached to the dump truck. To obtain a uniform cement spread, the spreader should be operated at a constant slow speed with a constant level of cement in the hopper. The mechanical cement spreader can also be attached directly behind a bulk cement truck. Cement is moved pneumatically from the truck through an air separator cyclone that dissipates the air pressure. Cement falls into the hopper of the spreader. Skirts are sometimes used to minimize windblown dusting. Placing dry portland cement in an uncontrolled manner by blowing under pressure should always be avoided.

Cement is most commonly applied dry, but can also be applied in a slurry form. With a slurry application, it is important that the slurry is dispersed uniformly over the placement area so that it will not pool or run off in any manner. Materials that contain excessive amounts of moisture will not mix readily with cement. However, granular materials can be mixed effectively with moisture contents slightly above optimum.

Procedures for applying water and mixing will depend on the type of mixing machine used. A thorough mixture of soil/ aggregate, cement, and water must be obtained. The uniformity of the mix is easily checked by digging trenches or series of holes at regular intervals for the full depth of treatment and inspecting the color of the exposed mixture. Uniform color and texture from top to bottom indicate a satisfactory mix, a streaked appearance indicates insufficient mixing.

Single-shaft traveling mixing equipment.

CTB construction with single-shaft traveling mixers varies depending on the type of equipment used. Some equipment can thoroughly mix the CTB in a single pass. Other equipment requires more than one mixing pass. However, the basic principles and objectives are the same. Shaping the roadway and scarification are the first steps of preparation. The larger mixers can scarify as well as mix an existing pavement surface and tough soil/aggregate material. For smaller equipment, the soil/aggregate may need to be loosened with a scarifier. Pre-wetting the soil/aggregate is common practice. Applying water at this stage of construction saves time during actual processing operations because most of the required water will already have been added to the soil/aggregate when cement is spread. Pre-wetting prevents cement from sifting to the bottom of the mix by causing it to adhere more readily to the soil/aggregate particles. Moisture should be applied uniformly during pre-wetting. Evaporation losses are reduced by incorporating this moisture into the mix. After scarifying and pre-wetting, the loose soil/aggregate is shaped to crown and grade.

Cement is spread by a mechanical cement spreader. Then the mixer picks up the soil/aggregate and cement and mixes them in place. Water, supplied by a tank truck, is usually applied to the mixture by the spray bar mounted in the mixing chamber, or water may be applied ahead of the mixer by water pressure distributors. The soil/aggregate and cement must be sufficiently blended when water contacts the mixture to prevent the formation of cement balls. The number of mixing passes depends on the type of mixer, the soil/aggregate characteristics and its moisture content, and on the forward speed of the mixer (figures 1.4-1.7).

Central-Plant Method

Revolving-blade pug-mills can be used for mixing non-plastic to slightly plastic soil/aggregate materials. Rotary-drum mixers are suitable for mixing course, non-plastic soil/aggregate materials. With batch-type pug-mills and rotary-drum mixers, materials are batch weighed, mixed, and placed into haul trucks. With continuous-flow-type pug-mills, materials are individually metered by weight or volumetrically prior to entering the pug-mill mixing operation. Each plant must be calibrated to make sure the proper quantity of material is entering the mixer.

The continuous-flow-type pug-mill plant is the most common. The plant setup is typified by a hopper or bulkhead feeder system containing the soil/aggregate, a cement silo, surge hopper and feeder, main feeder belt, and revolving-blade pug-mill mixer. Cement is usually metered onto the soil/aggregate main feeder belt just prior to entering the pug-mill. Water is metered and added by means of spray bars mounted above the pug-mill. The mixed material is discharged into a holding hopper and then into haul trucks.

There are three types of cement feeders in common use:

1. Auger or screw-type feeder
2. Belt feeder
3. Rotary-vane feeder

Each requires a surge tank or hopper for proper operation. The surge tank maintains a constant head of cement above the meter.

The calibration of a continuous-flow central plant is a relatively simple operation. First, the soil/aggregate is run through the plant for a short period and is collected and weighed. Then the cement meter is operated while soil/aggregate that is being run through the plant is collected and weighed. Adjustments are made until the correct proportion is attained. The speed of the cement meter is thus synchronized with the speed of the main feeder belt.

At the plant, additional moisture is added to compensate for moisture loss during transporting and spreading.

The mixed material is placed on a moist subgrade without segregation and is spread by an aggregate spreader, or by two spreaders operating side by side, or by an automatic string-line-controlled subgrade (figure 1.8).

Figure 1.4. Mixing in place using traveling mixing machines.

Figure 1.5. Mixing in place using traveling mixing machines (Wirtgen WR 2500).

Figure 1.6. Spreading portland cement

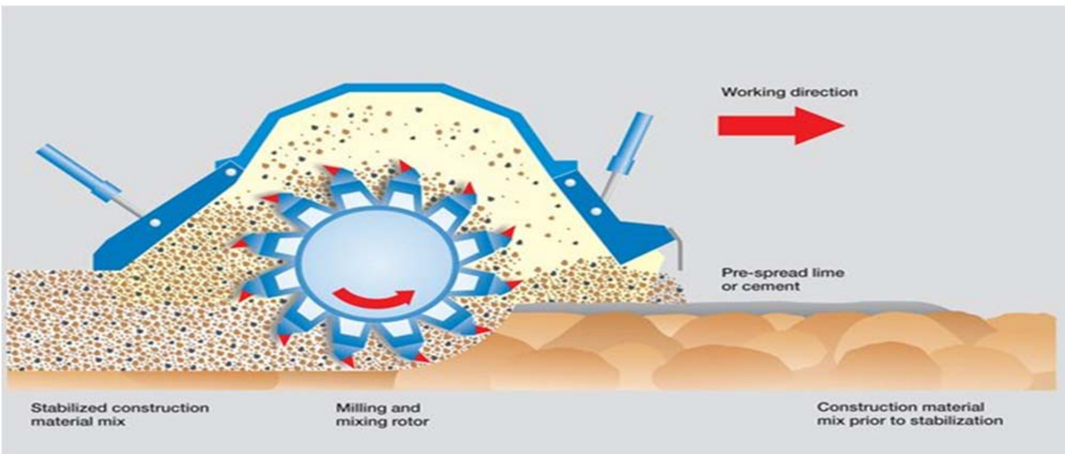


Figure 1.7. Process of mixing

Figure 1.8. Construction using paver machinery (central-mixing-plant)

Areas of unstable subgrade must be corrected before processing starts since proper compaction of CTB will not be possible if the subgrade cannot support the compaction equipment. Unstable subgrade soils, which usually contain excess moisture, can generally be detected by observing their stability under the wheels of the motor grader as it shapes the area prior to CTB processing. Shallow wet spots can be improved by aerating and drying. When deep unstable areas are encountered, it is usually necessary to remove the underlying soil and replace it with better material. An alternate method of correction is to treat the subgrade with cement. When in-place soil materials are used, the grade at the start of construction will influence the final cross-section. Therefore, before processing is started, the roadway should be shaped to approximate the crown and grade. Maintenance of crown and grade prior to CTB construction will permit rapid runoff of water during heavy rains and is good insurance against wet spots developing.

Cement Application

Since cement hydration practically ceases when temperatures approach freezing, cement should not be applied when the air temperature is 4° C or lower. The cement must not be applied when the soil material or subgrade is frozen. The amount of cement will be required is specified either as a percentage of cement by weight of oven- dry material, or kilograms per cubic meter of compacted CTB.

Bulk Cement spreaders should be operated at a constant slow rate of speed and a relatively constant level of cement kept in the hopper to obtain a uniform cement spread. A true line at the edge of the pavement should be maintained by using a string line. There should be no skips between spreading lanes.

A check on the accuracy of the cement spread is necessary to ensure that the proper quantity is actually being applied. When bulk cement is being used, the check is made in two ways:

1. Spot check. Place a canvas, usually 1 m2 in area,
2. Overall check. Check the distance of area over which a truckload of cement of known weight is spread.

When borrow materials are specified, central plants with pugmill-type mixers or rotary-drum mixers are often used to mix material-cement. The use of such equipment makes it necessary to proportion the cement and the aggregate before they enter the mixing chamber.

Water Application

One of the five control factors for CTB is proper moisture content. The optimum moisture content determined in the laboratory is used as a guide when starting construction. At the conclusion of moist-mixing, a moisture-density test, GOST 23558 and GOST 22733, is made on a representative sample of the mixture taken from the roadway. This test deters mines the optimum moisture and maximum density to be used for field control of the section under construction. These results may differ from laboratory values due to minor variations in the material or due to the effects of partial hydration of the cement during the mixing period.

The quantity of water required in central mixing plants to bring the CTB mixture to optimum moisture is based on the quantity of material and cement entering the plant.

Moisture for Compaction and Finishing

At the start of compaction, the moisture content of the CTB mixture must be at slightly above optimum. A final check of moisture is made at this time. Proper moisture is necessary for proper compaction and for hydration of the cement. Because of evaporation, it is better to have a slight excess of moisture than a deficiency when compaction begins. During compaction and finishing, the surface of the CTB mixture may become dry, as evidenced by the greying of the surface. When this occurs, very light applications of water are made to bring the moisture content back to optimum. A pressure distributor is used to make these fog applications of water. Proper moisture in the compacted CTB is evidenced by a smooth, moist, tightly knit surface free of checks, cracks, or ridges.

Compaction

The principles governing compaction of CTB are the same as those for compacting the same materials without cement treatment. The CTB mixture at optimum moisture should be compacted and finished immediately. Moisture loss by evaporation during compaction and finishing, indicated by a greying of the surface, should be replaced with light applications of water.

Tamping (sheep foot) rollers are generally used for initial compaction except for the more granular soils. To obtain adequate compaction, it is sometimes necessary to operate the rollers with ballast to give greater unit pressure. The general rule is to use the greatest contact pressure that will not exceed the bearing capacity of the soil-cement mixture and that will still ‘walk out" in a reasonable number of passes. When tamping rollers are used for initial compaction, the mixed material must be loose so that the feet will pack the bottom material and gradually walk out on each succeeding pass. Vibratory-steel-wheel rollers, grid rollers, and segmented rollers can be used satisfactorily to compact CTB made of granular soil materials. Vibratory-plate compactors are used on non-plastic granular materials.

Pneumatic-tire rollers can be used to compact coarse sand and gravel soil-cement mixtures with very little plasticity and very sandy mixtures such as dune, beach, or blow sand, which have little or no binder material. Some rollers permit rapid inflation and deflation of the tires while compacting.

Heavy three-wheel steel rollers can be used to compact coarse granular materials containing little or no binder. Gravelly soils that have low plasticity are best suited for compaction with these rollers.

For best results, compaction should start immediately after the material, cement, and water have been mixed. Required densities are then obtained more readily, there is less water evaporation, and daily production is increased.

Finishing

There are several acceptable methods for finishing CTB. The exact procedure depends on the equipment, job conditions, and material characteristics. Regardless of the method, the fundamental requirements of adequate compaction and optimum moisture must be met to produce a high-quality surface. The surface should be smooth, dense, and free of ruts, ridges, or cracks. When shaping is done during finishing, all smooth surfaces, such as tire imprints and blade marks, should be nail drag, coil spring, or spike-tooth harrow to remove cleavage or compaction planes from the surface. The reason for this is that a thin layer of CTB placed on top of these compaction planes may not adhere properly and in time may fracture, loosen, and spall. For a good bond, the area must be rough and damp. Scratching should be done on all CTB mixtures except those containing appreciable quantities of gravel. The surface should be kept damp during finishing operations. Steel-wheel rollers can be used to smooth out ridges left by the initial pneumatic-tire rolling. Steel-wheel rollers are particularly advantageous when rock is present in the surface. A broom drag can sometimes be used advantageously to pull binder material in and around pieces of gravel that have been set by the steel-wheel roller. Instead of using a steel-wheel roller, surfaces can be shaved with the motor grader and then rerolled with a pneumatic-tire roller to seal the surface. Shaving consists of lightly cutting off any small ridges left by the finishing equipment. Only a very thin depth is cut and all material removed is bladed to the edge of the road and should not be used. The final operation usually consists of a light application of water and rolling with a pneumatic-tire roller to seal the surface. The finished CTB is then cured. Regardless of the method used, the surface should be maintained at not less than optimum moisture content during finishing and the compacted surface should be smooth, dense, and free of compaction planes and cracks.

Curing

CTB at optimum moisture contains sufficient moisture for adequate cement hydration. After final compaction, a moisture-retaining cover is placed over the material-cement to permit the cement to hydrate. Moist material-cement is cured with bituminous material, but other materials such as waterproof paper or plastic sheets, wet straw or sand, fog-type water spray, and wet burlap or cotton mats are entirely satisfactory. The bituminous materials most commonly used are emulsified asphalt. Before the bituminous material is applied, the surface of the CTB should be moist and free of dry, loose material. In most cases, a light application of water precedes the bituminous cure. When the air temperature is expected to reach the freezing point, the CTB should be protected from freezing for 7 days after its construction and until it has hardened

Reflective Cracking

CTB will shrink naturally while curing. With properly designed pavements and good construction procedures, the resulting cracks in the base will not significantly affect pavement performance. In some cases, larger cracks in the base layer can result in stress concentrations, and the cracks may reflect from the base into the surface. This does not normally affect pavement roughness but may influence the overall appearance of the pavement. Usually, proper construction procedures, crack minimization strategies, and maintenance sealing, if necessary, can eliminate requirements for significant maintenance due to reflective cracking. Newer techniques such as microcracking or using stress absorbing interlayer have been very successful. A well designed and properly maintained CTB will normally outlast several asphalt overlays, providing decades of low maintenance service.

Special Construction Problems

Joint Construction

At the end of each day's construction, a transverse vertical construction joint is formed by cutting back into the completed soil - cement to the proper crown and grade. This is done usually the last thing at night or the first thing the following morning, using the toe of the motor grader blade or hand axes. After the next day's mixing has been completed at the joint, it is cleaned of all dry and unmixed material and re-trimmed if necessary. A longitudinal joint adjacent to partially hardened soil-cement can be constructed with most mixing equipment by merely cutting back a few inches with the mixer into the previously constructed area. The amount of overlap is determined by digging back into the completed work until solid material and proper crown and grade are reached.

Multiple-layer Construction

If the specified thickness of soil-cement is more than 20 cm, it cannot be thoroughly mixed, moistened, compacted and finished in one layer. Multiple layers have to be constructed with no layer less than 10 cm thick. The lower layer can be cured with moist soil that is subsequently used to build the top layer, which may be built immediately the following day or sometime later. The lower layer does not have to be finished to exact crown and grade, nor do surface compaction planes have to be removed since they are too far from the final surface to be harmful.

Rainfall

Wet weather need not be a serious construction hazard, but any loose or pulverized soil should be crowned so it will shed water, and low places in the grade where water may accumulate should be trenched so that they will drain freely. A light drizzle causes no harm. If rain falls during cement spreading operations, spreading is stopped and the cement already spread is quickly mixed into the soil mass. However, a heavy rainfall that occurs after most of the water has already been added may be serious. Generally, the best procedure is to obtain rapid compaction by using every available piece of equipment so that the section will be compacted and shaped before too much damage results from the rain. After the mixture has been compacted and finished, the rain will do no harm.

Cold Weather

Cement hydration practically ceases when temperatures are near or below freezing, therefore, soil-cement should not be placed when the temperature is 5 C or below. Moreover, it should be protected to prevent its freezing for a period of 7 days after placement and until it has hardened by a suitable covering of hay, straw or other protective material.

Soft Subgrade

If the subgrade is soft and cannot properly support the compaction equipment, adequate density will not be obtained. Therefore, soft areas such as springs, seepage areas, and differential frost-heave are should be located and corrected before processing begins. These areas can usually be stabilized by aerating and re-compacting the soil. When deep unstable areas are encountered, it is usually necessary to remove the underlying wet soil and replace it with stable material but the area may be sub processed with soil-cement or cement-modified soil.

1.2 Quality Control and Quality Assurance

The role of the inspection in CTB is a very essential one. There are five basic and fundamental factors that must be controlled to assure quality CTB.

If these five essentials can be controlled, a quality CTB project will then become a reality.

Field inspection of CTB construction involves the control of five factors:

- Cement content
- Moisture content
- Mixing
- Compaction
- Curing

The inspector can easily control these factors by organizing the inspection steps into a routine that fits in with the sequence of construction operations.

As below shown the inspection steps required to assure quality CTB:

- Have material surveys, laboratory reports, plans, and specifications (GOST or SHNK requirements) been reviewed and correlated with job conditions;
- Have all soft subgrade areas been corrected? Has the roadway been shaped to crown and grade? Have manhole covers and other obstacles been removed or lowered;
- Is all of the construction equipment properly adjusted and in good working condition;
- Have the materials been pulverized sufficiently, and will their moisture contents allow them to mix readily with cement;
- Has the proper quantity of cement been spread uniformly? Has the central mixing plant been properly calibrated;
- Is the CTB mixture between optimum moisture and 2% above optimum moisture;

- Is the mixture uniform and thoroughly mixed? Are the width and depth of treatment according to the plans;
- Is the finished surface moist, dense, and free of compaction planes;
- Is the CTB mixture at the transverse construction joint well mixed and compacted;
- Are the specified density and depth of treatment being achieved;
- Is sufficient curing material for complete coverage being applied;
- Where subjected to traffic, has the bituminous material been sanded sufficiently to prevent pickup;
- Have any defects been repaired for a full depth of treatment?

Determination of Cement Content

There are many methods used for determining the cement content. These methods are the Public Roads method, the ASTM method, the California method, the GOST method, and many others. For this paper the EDTA (Ethylenediaminetetraacetic acid) method is introduced, because the required testing time can be decreased by using this method. The detail of this method is as follows:

A 10 percent ammonium chloride solution is used as the solvent system for the calcium compounds present in cement-treated base materials. The solution is titrated with the disodium salt of EDTA after adjustment of pH, using hydroxy naphthol blue as an indicator. Cement content is determined from a standard graph after subtracting the aggregate blank [2].

Moisture Content Check

At the conclusion of moist-mixing, a moisture-density test is made on a representative sample of the mixture taken from the roadway. This determines the optimum moisture and maximum density to be used for field control of the section under construction. These results may differ from laboratory values due to minor variations in the soil or due to the effects of partial hydration of the cement during the mixing period. To determine the amount of water to add, first calculate the percentage of water in a sample of the raw soil or dry soil-cement mixture, as follows:

Percentage of moisture = ((wet weight - dry weight)/ dry weight) x100

The amount of water to be added during processing will be the difference between the required moisture content and the moisture content of the dry soil-cement mixture, as determined above.

Short Cuts Test

Many engineers have devised short cuts in making field moisture-density tests. For instance, the field sample, which is near optimum moisture, is split into three parts and one portion is used to establish a point near the peak of the moisture-density curve. The second portion of the material is then used with the addition of a small increment of water to establish a point on wet side of the curve. The third part of the original field sample which has dried slightly in the interim is used to establish a dry point on the curve.

Hand-squeeze Test

With a little experience, the moisture content of a soil-cement mixture can be estimated closely by observation and feel. A mixture near or at optimum moisture content is just moist enough to dampen the hands when it is packed in a tight cast. Mixtures above optimum will leave excess water on the hands, whereas mixtures below optimum will tend to crumble easily. If the mixture is near optimum, it is possible to break the cast into two pieces with little or no crumbling. The hand -squeeze test is not a replacement for the standard moisture-content test, but it does reduce the number of these tests required during construction. The moisture-determination test validates what has been determined by visual inspection and the hand-squeeze test.

Degree of Compaction Check

Density should be determined at several locations on the first few sections completed; the tests are made immediately after final rolling. A comparison of these densities with the results of the field moisture-density test indicates any adjustments in compaction procedures that may be required to ensure compliance with specifications. Specifications generally require that the density obtained shall be not less than the standard maximum minus 5 lb (2.26 kg). (some agencies specify not less than 95 percent of the maximum density) as determined by the field moisture-density test. After compaction procedures have been adjusted, only routine daily density checks are required. A density test is made by augering or digging a 5-inch diameter hole almost the full depth of processing. All material removed is carefully salvaged and the wet weight is measured; moisture content and oven-dry weight of this material are determined as follows:

$$M=((WW-DW)/DW)x100; \qquad (1.1)$$

$$DWH=WW)/(100+M)/100); \qquad (1.2)$$

The excavated hole is then filled with a material of known density the hole's volume is calculated by:

$$V=WHO/UWO; \qquad (1.3)$$

And then the density is determined as follows:

$$D= DWM/V. \qquad (1.4)$$

M- percent moisture of representative samp1e;

WW- wet weight;

DW- dry weight;

DWH- dry weight of material from test hole;

V- Volume;

WHO- the weight of material used to fill the hole;

UWO- unit weight of material;

D- density;

DWM-Dry weight of material removed from the hole.

The most common methods used for the volume determination of the density hole are.

1. Sand-cone method.

2. Balloon method.
3. Oil method.
4. Nuclear method [2].

1.3 Review of Literature

Vongchai Jarernswan in his study paid special attention to materials, the construction process and requirements.

Soil-cement is a low-cost highway material that can be constructed with only three basic raw materials: water, portland cement, and soil. The water should be clean and free from harmful amounts of alkalies and acid; many types of Portland cement conforming to ASTM Specifications can be used, and most of the soils at a site or nearby source are acceptable. In some conditions, the additives may be added to improve the properties or an economic standpoint.

Compressive strength is most frequently referred to as the important characteristic of soil-cement. The important factors that affect this strength are soil type, the quantity of cement, water content and compaction, curing condition, and age of soil-cement. Other pro- parties that should be considered are the durability, load-deflection characteristics, fatigue properties, shrinkage characteristics and cracking.

The use of soil-cement in the highway and airfield is on the increase every year because of its excellent properties and comparative economy over other materials. The research in this area has been continuing to improve the properties of soil-cement and to make soil- cement a more economical and more suitable material for engineering purposes [2].

Bryan T. Wilson in his study paid special attention to evaluated in terms of both strength and deformation characteristics at the time of construction and at 9 months.

Structural testing performed after 9 months of service indicated that the CTB stiffness and modulus were greater than the values measured after microcracking at the time of construction, indicating continued strength gain. Trafficking over the 9-month period had caused significantly lower stiffness's measured in the wheel paths than between the wheel paths, which were 226 and 244 kips/in (4035~4357 kg/mm) ., respectively. The corresponding module in and between the wheel paths were 469 and 705 ksi (3233~ 4860 Mpa). Though trafficking had a detrimental effect on both of these properties that may have been avoided if hot-mix asphalt surface had been placed, the likelihood of continuing reductions in stiffness and modulus with future trafficking in the wheel paths is unknown. The average unconfined compressive strength (UCS) of the cores tested at 9 months was not significantly different than the average UCS of the field-compacted specimens tested at 6 weeks, and insufficient evidence exists to suggest that trafficking caused reductions in UCS [3].

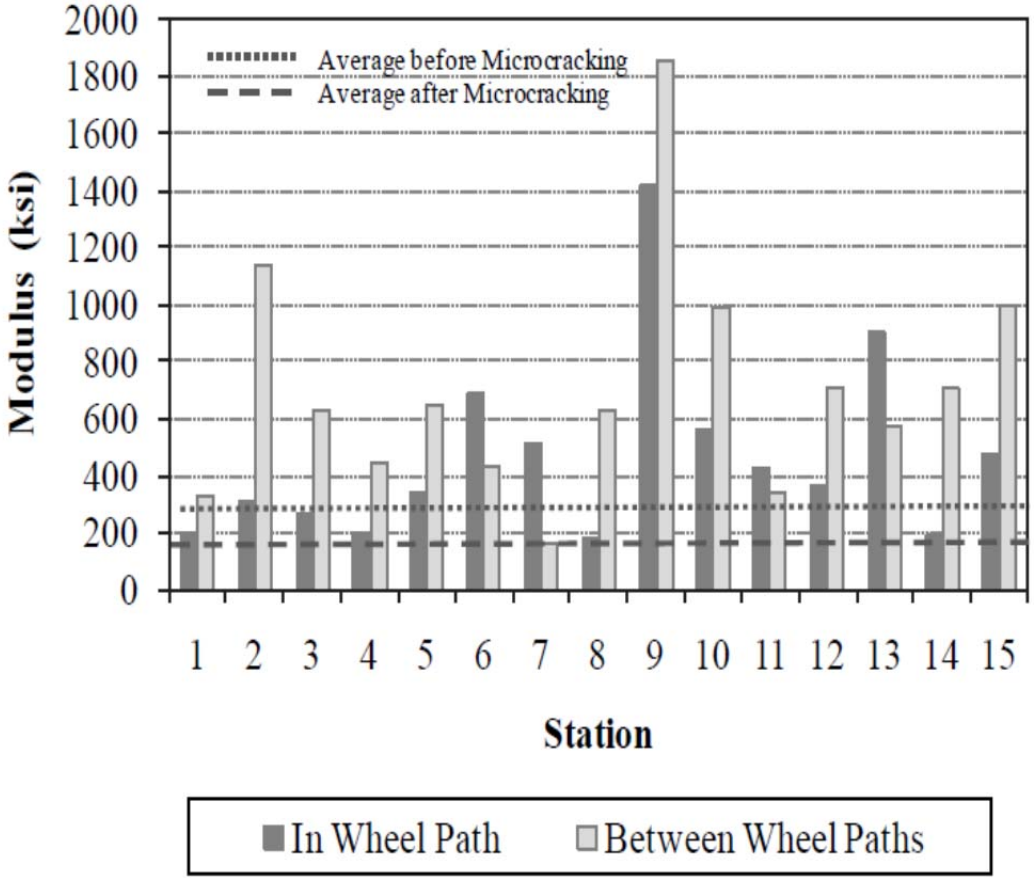


Figure 1.9. Nine-month CTB modulus

James Robert Fister in his study paid special attention to cracking in Cement Treatment Base.

Cracking that occurs in various types of soil-cement mixtures cannot be attributed entirely to the Type I Portland cement content ex-isting in the respective mixtures. The temperature differential existing in placed soil-cement bases i.e., the top surface at 140 F (60 C) and the bottom surface at 70 F (21), will in almost all cases cause a decreasing of the moisture content at the base courses upper surface even though 100 percent moisture retention is accomplished. This temperature differential also causes an increase in the moisture content at the bottom layer.

The effect of varying the moisture content 3 per cent above or below optimum moisture for maximum density results in different degrees of detrimental effects for different soils and their respective cement content, e.g., there exists a most favorable moisture content, which may or may not be equal for each different cement content used in a soil-cement mixture that will result in a minimum of cracking [4].

Liqun Hu in his study paid special attention to laboratory evaluation of cement treated aggregate containing crushed clay brick.

The waste clay bricks from the debris of buildings were evaluated through lab tests as environmentally friendly materials for pavement sub-base in the research Five sets of coarse aggregates which contained 0, 25% , 50% , 75% and 100% crushed bricks, respectively , were blended with sand and treated by 5% cement. The test results indicated that cement treated aggregate which contains crushed clay brick aggregate had a lower maximum dry density (MDD) and a higher optimum moisture content (OMC). Moreover, the unconfined compressive strength (UCS) , resilience modulus, splitting strength, and frost resistance performance of the specimens decreased with increase of the amount of crushed clay brick aggregate. The UCS decreased with the increase of crushed brick aggregate in the mixtures 7-day UCS of mixture which contains less than 50% crushed brick can meet the sub-base strength requirements of light traffic road in specifications [5].

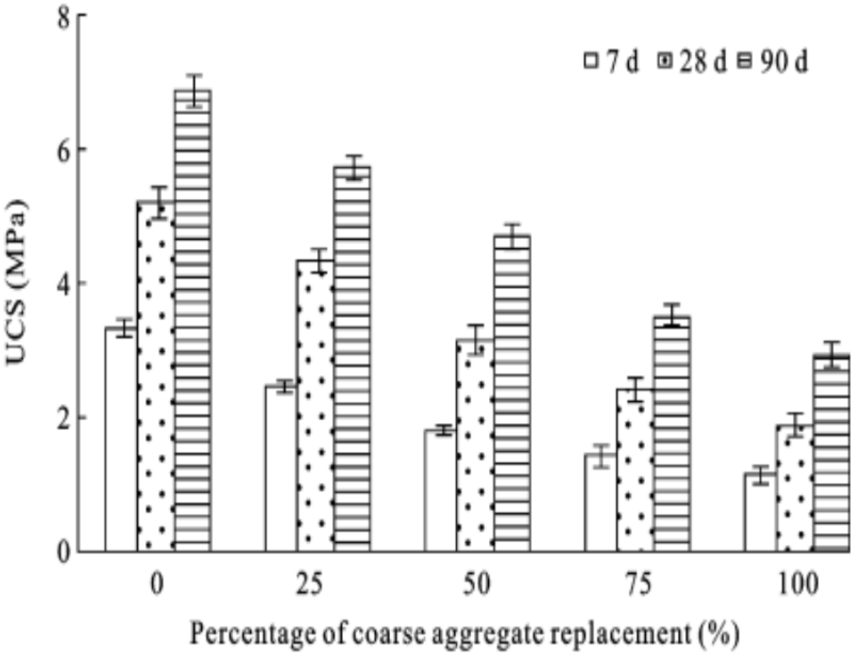


Figure 1.10. Test Results of Compressive strength

Yang Sheng in his study paid special attention to the relationship between compressive strength moisture, content and density.

CTB is a unique material that oversaturates the material in terms of water required for cement hydration which will increase the porosity of the cement matrix and thus reducing strength. However, pavement shear strength is dictated by density and therefore the OMC is to be used for optimum performance and workability when using CTB. The OMC for compaction of CTB is the OMC of the parent material + 0.25% for every 1% in cement content. This relationship runs parallel to the minimum water required for effective hydration to take place, i.e. a w/c ratio of 0.25. It is believed that this occurs due to the absorption of water by the cement paste for hydration and the reduction in fines due to the conglomeration of fines within the cement matrix [6].

Table 1.2

Compressive strength criteria of different classification of cement base course

Classification	Testing Criteria	Source
Modified	0.7 MPa < UCS < 1.5 MPa	Austroads
Lightly Bound (Stabilised)	1.5 MPa < UCS < 3 MPa	Austroads
Bound (Stabilised)	UCS > 3 MPa	Austroads
Lean Mix	6 MPa < f_{cm} < 15 MPa	DTMR
Conventional Concrete	f_{cm} < 20 MPa	Australian Standard

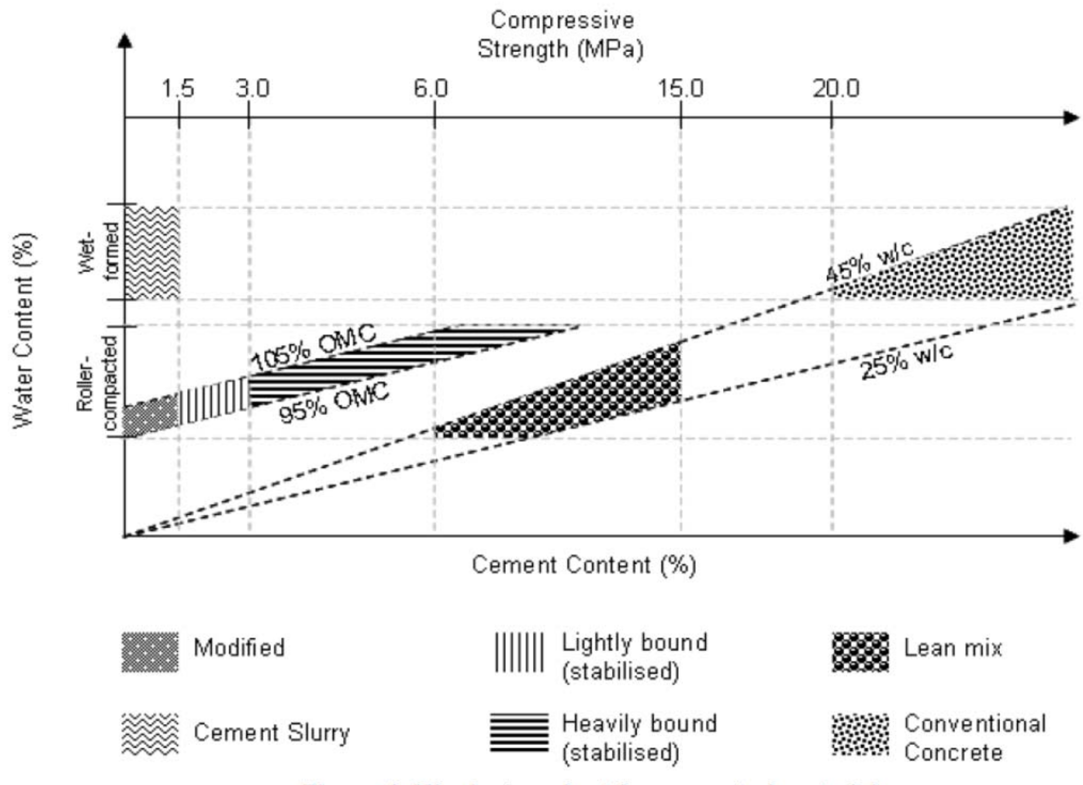


Figure 1.11. Mix design chart for cemented materials [6]

In the thesis, Kalankamary Pily George [7] paid special attention for Mix Design of Cement Treatment Base.

Microscopic studies by Bezruk [8] indicate that individual particles, as well as soil micro aggregations, take part in the reaction of cement with soil. He concludes that the interaction of cement with soil may be of a beneficial, detrimental or neutral in character. Variation of the col-loidal properties of soil favorable to interaction with cement increases the strength of the stabilized soil. Bezruk states that the most important qualitative difference between soil cement and concrete is that in soil-cement the cement hydrates in an active medium which disturbs the usual course of cement hydrolysis and hydration reactions. In concrete, the hardening proceeds essentially in an inert medium which plays mainly the role of a skeleton, with the cement hydrating in the products of its own dissociation.

Conclusions on the CHAPTER I

Conclusion of the chapter 1st summarized as follow:

- pavements with CTB will be much stronger and more rigid than an unsterilized, granular base. CTB thicknesses are less than those required for granular bases carrying the same traffic. It can distribute loads over a wider area, reducing the stresses on the subgrade and acting as the load-carrying element of flexible pavement or a sub-base for concrete. Its slab-like characteristics and beam strength are unmatched by granular bases that can fail when an aggregate interlock is lost. This happens when wet subgrade soil is forced up into the base by traffic loads.
- hard, rigid CTB is practically impervious. It resists cyclic freezing, rain, and spring-weather damage. CTB continues to gain strength with age even under traffic. This reserve strength accounts in part for CTB's excellent performance.
- the rigidity of CTB reduces deflection, rutting in the base and other asphalt strains. The versatility of cement is critical to the success in this pavement solution because site conditions and soil types (from gravel to clays) can easily change during or between projects and cement acts as a “universal stabilizer”.

During the literature review, no studies were found on the relationship between compressive strength and flexural strength. These two characters are the most important data for quality control and quality assurance.

CHAPTER II. EXPERIMENTAL STUDY OF THE CEMENT TREATMENT BASE

2.1 Required properties for CTB materials

❖ Technical Requirements for Cement

In accordance with subclause 4.3.1 of GOST 23558-94, CTB can be prepared using Portland cement and Portland Blast-Furnace Slag Cement (GOST 10178), Sulphate Resistance Portland Cement (GOST 22266) and ordinary cement (GOST 25328), and the mark shall not be less than M300.

• Portland cement and Portland Blast-Furnace Slag Cement (GOST 10178)

- The ultimate bending and compressive strength of cement shall not be less than the values specified in Table 2.1.

Table 2.1

Ultimate bending and compressive strength of cement

Designation of Cement	Guaranteed Grade	Ultimate Strength MPa (kgf/cm^2)			
		Bending Strength Age, days		Compressive Strength Age, days	
		3	28	3	28
ПЦ-Д0, ПЦ-Д5, ПЦ-Д20, ШПЦ	300	-	4,4 (45)	-	29,4 (300)
	400		5,4 (55)		39,2 (400)
	500		5,9 (60)		49,0 (500)
	550		6,1 (62)		53,9 (550)
	600		6,4 (65)		58,8 (600)
ПЦ-Д20-Б	400	3,9 (40)	5,4 (55)	24,5 (250)	39,2 (400)
	500	4,4 (45)	5,9 (60)	27,5 (280)	49,0 (500)
ШПЦ-Б	400	3,4 (35)	5,4 (55)	21,5 (220)	39,2 (400)

- Cement shall indicate an even change in the volume in the process of boiling testing of samples in water, and autoclave testing for cement with the MgO content in clinker of more than 5%;
- The beginning of the cement setting shall not be earlier than 45 min.; and the end – not later than 10 hours from the beginning of mixing cement with water.
- The fineness of cement shall allow not less than 85% of the weight of a sieved cement sample to go through the testing sieve with net No. 008 according to GOST 6613.
- The weight fracture of sulfuric acid anhydride (SO_3) in cement shall comply with the requirements of Table 2.2.

Table 2.2

Weight fracture of sulfuric acid anhydride (SO_3)

Designation of Cement	SO_3, % of the weight	
	Not less than	Not more than
ПЦ 400-Д0, ПЦ 500-Д0, ПЦ 300-Д5, ПЦ 400-Д5, ПЦ 500-Д5, ПЦ 300-Д20, ПЦ 400-Д20, ПЦ 500-Д20	1.0	3.5
ПЦ 550-Д0, ПЦ 600-Д0, ПЦ 550-Д5, ПЦ 600-Д5, ПЦ 550-Д20, ПЦ 600-Д20, ПЦ 400-Д20-Б, ПЦ 500-Д20-Б	1.5	4.0
ШПЦ 300, ШПЦ 400, ШПЦ 500, ШПЦ 400-Б	1.0	

- Sulfate -resistance Portland Cement (GOST 22266)
- Design mineralogical composition of clinker used for the production of cement shall conform to requirements specified in table 2.3.

Table 2.3

Mineralogical composition of clinker

<table>
<tr><th rowspan="2">Name of Index</th><th colspan="4">Value for clinker, % by weight, maximum for cement of the following types</th></tr>
<tr><th>Sulfate-resistant cement</th><th>Sulfate-resistant Portland cement with mineral admixtures</th><th>Sulfate-resistant slag Portland cement</th><th>Pozzolan Portland cement</th></tr>
<tr><td>Content of tricalcium silicate (3 CaO SiO_2) (3 CaO molecules per 1 SiO_2 molecule)</td><td>50</td><td colspan="3">Not normalized</td></tr>
<tr><td>Content of tricalcium aluminate (3 CaO Al_2O_3)</td><td colspan="2">5</td><td colspan="2">8</td></tr>
<tr><td>Total Content of tricalcium aluminate (3 CaO Al_2O_3) and tetracalcium aluminoferrite (4 Ca Al_2O_3 Fe_2O_3) (4CaO molecules per 1 Al_2 O_3 molecule and 1 Fe_2O_3 molecule)</td><td colspan="2">22</td><td colspan="2">Not normalized</td></tr>
<tr><td>Contents of aluminum oxide (Al_2O_3)</td><td colspan="4">5</td></tr>
<tr><td>Contents of magnesium oxide (MgO)</td><td colspan="4">5</td></tr>
</table>

- Content of sulfuric acid anhydride (SO_3) in cement shall not exceed values specified in table 2.4

Table 2.4

Content of sulfuric acid anhydride (SO_3) in cement

Type of Cement	**Content of SO_3** (in %, maximum)
Sulfate-resistant Portland cement	3.0
Sulfate-resistant Portland cement with mineral admixture	3.0
Sulfate-resistant slag Portland cement	4.0
Pozzolanic Portland cement	3.5

- Flowability of cement-sand mortar with the composition of 1:3 from water reducing elements of all kinds shall have such a value that for a water-cement ratio equal to 0.4 the spread of standard flow cone (mortar spread) is not less than 135 mm.
- To intensify the grinding process in the course of cement production it is allowed to introduce technological admixtures that do not impair the quality of cement, in the quantity of not more than 1% from cement mass.
- The compression strength of cement shall not be less than the values specified in table 2.5

Table 2.5

Compressive strength of cement

Type of cement	Grade of cement	Compression strength at the age of 28 days
Sulfate-resistant Portland cement	400	39.2
Sulfate-resistant Portland cement with mineral admixtures	400 500	39.2 49.0
Sulfate-resistant slag	300	29.4

- The beginning of cement setting shall occur not earlier than in 45 minutes, and the end – not later than in 10 hours after the beginning of addition of water to cement;
- Fineness of cement grinding determined by a specific surface shall not be less than 250 m2/kg. For cement containing admixtures of sedimentary nature the thinness of cement grinding shall be determined by residue on a sieve with mesh No. 008 in accordance with GOST 6613. Residue on a sieve shall not be more than 15% from the mass of a sieved sample.

❖ Technical Requirements for Crushed stone and Gravel

- Crushability indices for crushed aggregate produced from sedimentary and metamorphic rocks shall be in conformance with the requirements listed in Table 2.6. Crushability categories for crushed aggregate produced from volcanic rocks are provided in Table 2.7.

Table 2.6

Crushability index

Crushability index for crushed rock produced from sedimentary and metamorphic rocks	Weight loss at crushed rock testing, %	
	Dry	Saturated with water
1200	Up to 11 inclusively	Up to 11 inclusively
1000	Over 11 to 13	Over 11 to 13
800	13 to 15	13 to 15
600	15 to 19	15 to 20
400	19 to 24	20 to 28
300	24 to 28	28 to 38
200	28 to 35	38 to 54

Table 2.7

Crushability index

Crushability index for crushed rock produced from volcanic rocks	Weight loss at a crushed rock test, %	
	Intrusive rock	Effusive rock
1400	Up to 12, inclusively	Up to 9, inclusively
1200	Over 12 to 16	Over 9 to 11
1000	16 to 20	11 to 13
800	20 to 25	13 to 15
600	25 to 34	15 to 20

- Freeze-thaw resistance number of crushed rock and gravel shall be characterized by the number of freeze and thaw cycles, when the percentage loss of crushed rock and gravel weight does not exceed the established values.

It is allowed to evaluate the freeze-thaw resistance of crushed rock and gravel by the number of saturation (in a sodium sulfate mixture) and drying cycles. When the numbers obtained by different methods do not conform, freeze-thaw resistance shall be evaluated by freeze and thaw test results. According to freeze-thaw resistance, crushed rock and gravel are divided into the following grades: F15; F25; F50; F100; F150; F200; F300; F400. When tested by freezing and thawing or saturating in a sodium sulfate mixture and drying, freeze-thaw resistance values of crushed rock and gravel shall be in conformance with those listed in Table 2.8.

Table 2.8

Crushed rock and gravel freeze-thaw resistance

Type of test	Crushed rock and gravel freeze-thaw resistance number							
	F15	F25	F50	F100	F150	F200	F300	F400
Freezing-thawing: number of cycles	15	25	50	100	150	200	300	400
Weight loss after the test, % no more than	10	10	5	5	5	5	5	5
Saturation in a sodium sulfate mixture - drying: Number of cycles	3	5	10	10	15	15	15	15
Weight loss after the test, % no more than	10	10	10	5	5	3	2	1

❖ Technical Requirements for Sand

- Each sand group is characterized by a size module value indicated in Table 2.9

Table 2.9

Module size of Sand

Sand Group	Size Module, M size
Large oversize	Over 3.5
Oversize	3.0-3.5
Coarse-grained	2.5-3.0
Medium-grained	2.0-2.5
Fine-grained	1.5-2.0
Ultrafine-grained	1.0-1.5
Thin	0.7-1.0
Ultra-thin	Up to 0.7

- Clayey and dusty particle content in the sand, as well as clay lump, shall not exceed the values indicated in Table 2.10.

Table 2.10

Clayey and dusty particle content in sand

Sand Class and Group	Dusty and Clayey Particles Content		Clay Lump Content	
	In natural sand	In screened sand	In natural sand	In screened sand
Class I				
Large oversize	-	3	-	0.35
Oversize, coarse and medium	2	3	0.25	0.35
Fine	3	5	0.35	0.50
Class II				
Large oversize	-	10	-	2
Oversize, coarse and	3	10	0.5	2
Fine and ultra fine	5	10	0.5	2
Thin and ultrathin	10	non-standard	1.0	0.1*

❖ Technical Requirements for Water

- The content of organic surfactants, sugars or phenols, each of them, shall not be over 10 mg/l.;
- Water shall not contain petroleum product films, fats, and oils;
- The water oxidability shall not be over 15 mg/l.;
- The water pH value shall not be less than 4 and over 12.5.

❖ Additives

The quality of CTB has been improved in many cases through the addition of suitable additives. Research at the Massachusetts Institute of Technology Soil Stabilization Laboratory has been conducted to improve the properties of soil-cement by the use of chemical additives. The test results indicate that a very large increase in the strength of soil-cement can be obtained with low- level chemical treatment. Both a considerable financial saving and a successful stabilization of soils which normally cannot be economically stabilized can result from the use of additives with soil-cement.

A further advantage of the use of additives is that considerable construction and cure time can be saved because a number of the chemicals accelerate the rate of strength development of soil-cement. The durability tests by (9) indicate that the effects of the additives on durability, as measured by the standard freeze-thaw and wet-dry tests, were similar to the effects on compressive strength. The summary of test results from references (9) and (10) will give some idea of the kind of additives for use in some cases.

a. Calcium and magnesium sulfates, in addition to sodium sulfate, are found to be very effective in increasing the strength of organic sand -cement.

b. The silicates of high soda content are very effective in improving strength.

c. Sodium additives considerably increase the resistance of all types of soil-cement to sulfate attack.

d. Sulfate compounds are uniquely effective in improving the strength of cement-stabilized sandy soils containing organic matter.

f. The effectiveness of sodium hydroxide in clay-cement can be materially improved by pretreating the heavy clays with secondary additives.

j. Pretreatment of salty soils with caustic soda diminished the beneficial effects obtained by the incorporation of this additive simultaneously with the cement.

k. Hydroxides or weak-acid salts of an alkali metal, which yields soluble silicates (or aluminates) are beneficial to soil-cement.

l. Sodium met silicate was the most effective on the clean sandy soils.

m. The effectiveness of sodium compounds decreased with increasing plasticity and /or organic matter of the soil.

n. Soil containing free sodium chloride was much less responsive to cement-stabilization than was the same soil after salt removal.

p. The 28-day strength of additive treated soil-cement was virtually independent of additive concentration when the latter was above a certain minimum (0. 5 to 1. 0 normal).

q. The strength increase of soil-cement due to the addition of alkaline sodium compounds appeared to be permanent.

r. The magnitude of strength increase obtained by the addition of alkaline sodium compounds appeared to increase with the amount of reactive silica present in a soil.

To investigate the effect of dispersant additives on the physical characteristics of CTB mixes and layered pavement systems, the tests show that there is a definite increase produced in the shear strength of the layered system by developing a bond between adjacent layers of a soil-cement stabilized system with the addition of calcium lingo-sulfate and hydroxylated carboxylic acid for soils of low plasticity with the exception of pure silts. The study of (1) in search of treatments to reduce shrinkage led to several promising additives; lime and fly ash proved to be the best. Sulfates of magnesium, sodium, and calcium and expansive cement, by virtue of their ability to expand and compensate for the shrinkage, are the second best additives.

2.2 Required Laboratory Testing for Cement Treatment Base in local and in International Standard Specifications

❖ Sieve analysis

- In accordance with sub-clause 4.2.5 of GOST 23558-94 the sieve analysis (gradation) of sand-gravel (crushed stone) mixtures must meet the requirements specified in Table 2.11.

Table 2.11

Gradation of Cement Treatment Base materials

Max. grain size, mm	Total remains on sieves with hole size, mm									
	40	20	10	5	2,5	1,25	0,63	0,315	0,14	0,005
40	0-10	20 - 40	35-65	50-80	60-85	70-90	75-95	80- 97	85-98	87-100
20		0-10	20-40	35-65	50-80	60-85	70-90	75-95	80-97	85-100
10			0-10	25-40	45-65	60-80	70-85	75-90	80-95	85-100
5				0-10	30-40	50-65	65-80	75-85	80-90	88-100
2,5					0- 10	30-40	55-65	70-80	80-90	88-100
1,25						0-10	35-45	60-70	75-85	85-100

❖ The compressive and flexural strength

- The compressive strength and flexural strength are determined in accordance with GOST 10180. Samples of processed materials and stapled grains used in the regions with a median temperature of the coldest month minus 10 ° C and lower before being tested are poured into the water for saturation for

48 hours. First, the samples are poured into the water 1/3 at altitudes, and after 6 hours - completely and emit 42h. The samples of processed materials and stapled grains used in regions with a median temperature of the coldest month above minus 10 ° C are subjected to a capillary water saturation test for 72 hours before testing. Capillary water saturation of samples conducts through a layer of moist sand. In a metal or glass vessel with a level meter, pour the water to the level indicated in Figure 2.1. With the help of a leveler, a constant level of water in the vessel is maintained. In a vessel on a metal stand, a metal mesh is laid or a container with a mesh bottom is installed, which is closed with filter paper. A layer of fine uncolored sand is poured onto the filter paper and put the samples a day after saturation. To prevent drying, the vessel with specimens is placed in a bath with a hydraulic seal.

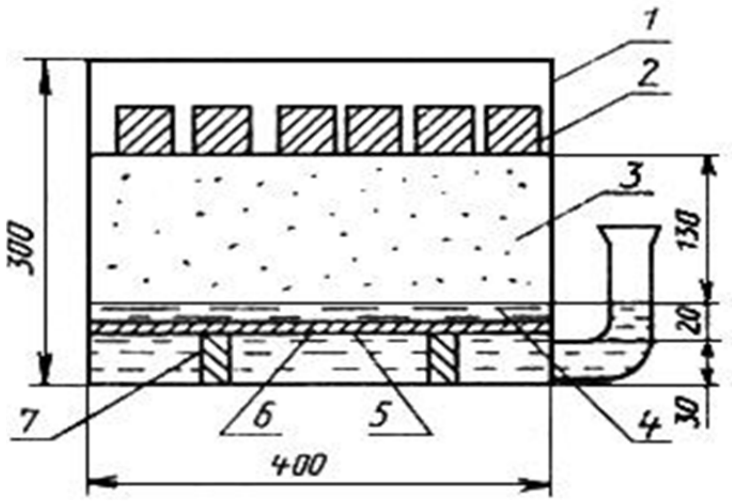


Figure 2.1. Scheme of the device for capillary water saturation of samples

1 - vessel; 2 - samples; 3 - capillary-moistened sand; 4 - water; 5 - filter paper; 6 - metal mesh; 7 – stand.

The strength of the samples of the processed material and the consolidated granite, depending on the type of binder used for processing, is determined in the following drafts:

28 days - for the binder of type I;

It is allowed to determine the strength of the samples of the processed material and the consolidated sheet in the following intermediate periods: 7 days - for astringents of the first type. It is allowed at the transition from one type of test to the other to determine the strength for elongation when pumping through the formula:

$$R_{р} = 0{,}5 R_{изг} K \quad (2.1)$$

$R_{изг}$- flexural strength MPa (kgf/cm2);

K= 08,-1,2 coefficient, clarified in the selection of the composition on specific materials and depending on the technical characteristics of the materials and grains used.

The frost resistance of processed materials and reinforced grains is determined by the first method in accordance with GOST 10060.1. The main and control samples before the test for frost resistance are saturated with water according to 6.1 of this standard. After passing the required number of freeze-thaw cycles, the samples are discharged from the camera and immersed in water at a temperature of (20 ± 2) ° C, if they were subjected to full water saturation, or to wet sand (sawdust), before they were tested for frost resistance, if they were subjected to capillary water saturation. The time for setting up samples in water or in wet sand should correspond to the time of thawing in accordance with GOST 10060.1, after which the samples should be tested for compression and determined their strength according to GOST 10180.

The maximum density of processed materials and cemented grains for the selection of concrete mixes and preparation of samples is determined in accordance with GOST 22733 with the following change: for the preparation and testing of samples of mixtures with a maximum grain size of not more than 20 mm, a large unit of the Union is used. In the form of a large mixture, the mixture is covered in three steps, piercing each layer 25 times with a metal staple diameter of 12 mm. After laying the entire mixture, it is compacted in one line by 120 hammer blows with a mass of 2.5 kg falling from a height of 30 cm. For the preparation and testing of samples of mixtures with a maximum grain content of up to 5 mm, a small unit of the Union is used. In the form of a small device, the mixture is covered and pierced 25 times with a metal stitch, then compacted with 20 blows of a 2.5 kg gypsum falling from a height of 20 cm.

It is permissible for the mixture to be tested by pressing, using for samples with a maximum strength of up to 5 mm, sample cubes with a size of 50 and 100 mm or a beam with a size of 40x40x100 mm, and for a mixture with a maximum strength of up to 20 mm, beams with a size of 100x100x400 mm. The orientation pressure of the feed for a mixture with a maximum strength of up to 5 mm is 15 MPa, a maximum of 20 mm is 20 MPa, the time for under load is 3 minutes.

The durability of the processed material and the consolidated granite in the project age is characterized by the mark. The ratio between the mark by strength and compressive strength and elongation during bending should meet the requirements specified in Table 2.12.

Table 2.12

The ratio between the compressive strength and flexural strength

Mark for strength	Strength, MPa (kgf/cм2), not less than	
	Compressive strength	Flexural strength
M10	1,0 (10)	0,2 (2)
M20	2,0 (20)	0,4 (4)
M40	4,0 (40)	0,8 (8)
M60	6,0 (60)	1,2 (12)
M75	7,5 (75)	1,5 (15)
M100	10,0 (100)	2,0 (20)

According to the frost resistance, the processed materials and strengthened soils are divided into the following grades: F5, F10, F15, F25, F50, and F75. For the stamp on frost resistance, the set number of cycles of the freezing and thawing are determined, at which the reduction in compressive strength is not more than 25% of the rated strength in the design age.

In accordance with sub-clause 5.2.2 of O'zDSt 3074:2016 the compressive strength must meet the requirements specified in Table 2.13 [11].

Table.2.13

Compressive Strength of roller-compacted concrete

Mark	Compressive strength, MPa (kgf/cm^2)
UB75	7,5 (75)
UB100	10,0 (100)
UB150	15,0 (150)
UB200	20,0 (200)
UB250	25,0 (250)
UB300	30,0 (300)
UB350	35,0 (350)

In accordance with sub-clause 3.1.8 of IKN 109-15 "…roller-compacted concrete is not carried out for flexural strength during calculation the strength of the layer (flexible pavement)…" [12].

Technical requirements for CTB in International Standards

According to the Texas Department of Transportation's (TxDOT) "Standard Specifications for Construction and Maintenance of Highways, Streets, and Bridges" for the Cement Treatment Base specified as below requirements:

- For Mix Design (Road-Mixed).

The Engineer will determine the target cement content and optimum moisture content to produce a stabilized mixture that meets the strength requirements shown on the plans. The mix will be designed in accordance with Tex-120-E or will be based on prior experience with the project materials. The

Contractor may propose a mix design developed in accordance with Tex-120-E. Meet strength requirements when shown on the plans. The Engineer will use Tex-120-E to verify the Contractor's proposed mix design before acceptance. Reimburse the Department for subsequent mix designs or partial designs necessitated by changes in the material or requests by the Contractor.

- For Mixing (Road-Mixed).

Thoroughly mix the material and cement using approved equipment. Mix until a homogeneous mixture is obtained. Sprinkle the treated materials during the mixing operation, as directed, to maintain optimum mixing moisture. Spread and shape the completed mixture in a uniform layer. After mixing, the Engineer may sample the mixture at roadway moisture and test in accordance with Tex-101-E, Part III, to determine compliance with the gradation requirements in Table 2.13. When strength requirements are shown on the plans, the Engineer may sample the mixture to verify strength in accordance with Tex-120-E and adjust cement content to achieve the target strength for work going forward.

Table 2.14

Gradation Requirements Minimum % Passing

Size	Base	Subgrade
1-3/4″ (25.4-19.0 mm)	**100**	**100**
3/4″ (19.0 mm)	**85**	**85**
#4 (4.76 mm)	**–**	**60**

- For Compaction (Road-Mixed).

Compact the mixture in one lift using density control unless otherwise shown on the plans. Complete compaction within 2 hours after the application of water to the mixture of material and cement. Sprinkle the treated material in accordance with Item 204, "Sprinkling," or aerate the treated material to adjust the moisture content during compaction so that it is within 2.0 percentage points of optimum as determined by Tex-120-E**.** Measure the moisture content of the material in accordance with Tex-115-E or Tex-103-E during compaction daily and report the results the same day to the Engineer, unless otherwise shown on the plans or directed. Adjust operations as required. Begin rolling longitudinally at the sides and proceed towards the center, overlapping on successive trips by at least one-half the width of the roller unit. On superelevated curves, begin rolling at the low side and progress toward the high side. Offset alternate trips of the roller. Operate rollers at a speed between 2 and 6 mph, as directed. Before final acceptance, the Engineer will select the locations of tests in each unit and measure the treated depth in accordance with Tex-140-E. Correct areas deficient by more than 1/2 in. in thickness or more than 1/2% in target cement content by adding cement as required, reshaping, re-compacting, and refinishing at the Contractor's expense. Remove or rework areas that lose required stability, compaction, or finish, as directed. When a section is reworked more than 4 hr. after completion of compaction, add additional cement as directed. Provide additional work and material at no additional cost to the Department.

- For Density Control (Road-Mixed).

Achieve at least 95% of the maximum density determined in accordance with Tex-120-E when compaction is complete. The Engineer will determine roadway density and moisture content in accordance with Tex-115-E. The Engineer may verify strength in accordance with Tex-120-E and adjust cement content to achieve the target strength for work going forward. Remove material that does not meet density requirements or rework by adding the target cement content, reshaping, re-compacting, and refinishing at the Contractor's expense.

- Mix Design *(Plant-Mixed)*

Using the materials proposed for the project, the Engineer will determine the target cement content and optimum moisture content necessary to produce a stabilized mixture meeting the strength requirements shown in Table 2.15 for the class specified on the plans. The mix will be designed in accordance with Tex-120-E. The Contractor may propose a mix design developed in accordance with Tex-120-E._The Engineer will use Tex-120-E_to verify the Contractor's proposed mix design before acceptance. The Engineer may use project materials sampled from the plant or the quarry, and sampled by the Engineer or the Contractor, as determined by the Engineer. Limit the amount of asphalt concrete pavement to no more than 50% of the mix unless otherwise shown on the plans or directed [13].

Table 2.15

Strength Requirements

Class	7-Day Unconfined Compressive Strength, Min psi
L	500 (35.15 kgf/cm^2)
M	300 (21.09 kgf/cm^2)
N	As shown on the plans

In accordance with American Society for Testing and Materials (ASTM) D1635-00 “Standard Test Method for Flexural Strength of Soil-Cement Using Simple Beam with Third-Point Loading” required value and deviation for Flexural strength of CTB as below (table 2.16):

Table 2.16

Strength Requirements

Cement Content	Average Flexural strength, psi (kgf/cm^2)	Standard deviation, psi	Coefficient of variation, %
Specimens with 6% cement	94 (6.7)	6	6.4
Specimens with 14%	157 (11.04)	9	5.7

Length, calculate the modulus of rupture as follow:

$$\mathbf{R=PL/bd^2} \qquad (2.2)$$

Where:

R=modulus of rupture, kPa (psi),

P=maximum applied a load, N (lbf),

l= span length, mm (in),

b= average width of the specimen, mm (in), and
d= average depth of specimen, mm (in).

If the fracture occurs outside the middle third of the span length by not more than 5% of the span length, calculate the modulus or rupture as follows:

$$\mathbf{R=3Pa/bd^2} \qquad (2.3)$$

Where:
a= distance between the line of fracture and the nearest support, measured along the center line of the bottom surface of the beam.
If the fracture occurs outside the middle third of the span by more than 5% of the span length, discard the results of the test [14].

2.3 Materials and CTB Testing

Two kinds of coarse aggregates were prepared to study. One is natural aggregate (from the gravel-sand mix) and the other is crushed aggregate. The crushed stone value, flakiness index, and elongation index, percent fractured face, clay content, clay in lumps, durability, Los Angeles abrasion and frost resistance were conducted in accordance with GOST 8269.0-97 "Crushed stone and gravel from dense rock and industrial waste for construction work. Methods of physical and mechanical testing". The crushed stone values are shown in table 2.17.

Table 2.17

Test results of crushed aggregate

Name of Tests	Requirements according to the GOST 8267-93	Test Results of Crushed aggregate
Flakiness Index and Elongation Index	Maximum 25%	15.2 %
Percent Fractured Face	Minimum 80%	83.3%
Clay Content	Maximum 1%	0.88%
Clay in lumps	Maximum 0.25%	0.1%
Durability (mark)		800 (13.1%)
Los Angles Abrasion	Up to 25%	И-1 (10,5%)
Frost resistance	F100	F100

The test results show that the crushed aggregate meets with the requirements of GOST 8267-93.

The cement supplied by OHANGARONSEMENT" JSC is grade M400-DO Sulfate Resistance Portland Cement with the density of 3140 kg / m3. The Cement value, compressive strength setting time and others were conducted according to GOST 310.1-310.4 "Cement. Test Method. General.", "Cement. Methods of grinding fineness determination", "Cement. Methods for determination of standard consistency, times of setting and soundness" and "Cement. Methods of bending and compression strength determination”. The cement test results are shown in table 2.18.

Table 2.18

Test results of cement

Name of Tests	Requirements according to the GOST 22266-94	Test Results of cement
28 days Compressive strength MPa (kgf/cm2)	39,2 (400)	40,3 (409)
Setting time, h. min - Starting - Finish	 Not earlier than 0:45 Not later than 10:00	 2-15 4-25
Fineness of cement (No.008),%	Minimum 85	90
sounding of cement, mm	Shall comply	complies
Content of SO3,%	Not more than 3.0	2.0
Content of chloride-ion CL,%	Not more than 0.1	0.06

A special chemical laboratory and equipment are required for testing cement clinker. Thus, the manufacture’s laboratory test results were used for research. The cement clinker test results are shown in table 2.19.

Table 2.19

Test results of cement clinker

Name of Tests	Requirements according to the GOST 22266-94	Test Results of cement
Aluminum oxide	Not more than 5.0	4.78
Magnesium oxide	Not more than 5.0	2.28
Alkali oxides	As per contract	0.88
Tricalcium silicate ($3CaO\ SIO_2$)	Not more than 50	49.78
Tricalcium aluminate (C_3A)	Not more than 5.0	3.59
Total tricalcium aluminate ($3CaO\ AL_2O_3$) and tetracalcium aluminate ferrite ($4Ca\ AL_2O_3$	Not more than 22.0	19.85

The test results show that the cement including clinker meets the requirements of GOST 22266-94.

A special chemical laboratory and equipment are required for testing water. Thus, water was sampled in accordance with GOST 24481-80 and delivered to the Sanitary and Epidemiological Service laboratory. The water tested in accordance with GOST 3351-74, GOST 4245-72, GOST 4389-72, and GOST 18164-72. The water test results are shown in table 2.20.

Table 2.20

Test results of water

Data	**Requirements acc. Standard**	**Results**
Odor threshold 20^{o}C 60^{o}C	Not more than 2 ball	 0 0
Smack		0
Color index	Maximum 30^O	0
Residue		no
pH	6.5-8.5	7.7
Oxidizability	6-7.0	-
Azote in ammonia	Maximum 2 mg/l	0
Azote in nitrites	Maximum 3 mg/l	0.037
Azote in nitrates	Maximum 45 mg/l	2.0
Hardness	Maximum 7.0	4.2
Dry residue	Maximum 1500 mg/dm3	230
Chlorides	Maximum 350 mg/dm3	36
Sulfates	Maximum 500 mg/dm3	32

The test results show that the water meets the requirements of sub-clause 4.4 of GOST 23558-94.

The mix design was prepared using 30% of crushed aggregate (CA) and 70% gravel sand mix (GSM). To analyze the gradation of the mix, sieve analysis were conducted in accordance with GOST 8269.0-97 **and** GOST 8735-88. The mix test results are shown in table 2.21. and graph 2.1.

Table 2.21

Sieve analysis of CA with GSM

Sieve No., (mm)	Weight of Retained, (g)	Percentage of Retained, (%)	Total Weight of Retained, (g)	Total Percentage of Retained, (%)	Spec Limits, (%)	
40	650,00	1,14	650,00	1,1	0,0	10,0
20	14000,00	24,51	14650,00	25,6	20,0	40,0
10	8560,00	14,99	23210,00	40,6	35,0	65,0
5	8960,00	15,69	32170,00	56,3	50,0	80,0
2,5	6551,00	11,47	38721,00	67,8	60,0	85,0
1,25	5954,00	10,42	44675,00	78,2	70,0	90,0
0,64	6270,00	10,98	50945,00	89,2	75,0	95,0
0,315	4122,00	7,22	55067,00	96,4	80,0	97,0
0,14	1004,00	1,76	56071,00	98,2	85,0	98,0
0,005	933,00	1,63	57004,00	99,8	87,0	100,0
Pan	118,00	0,21	57122,00	100,0		
Total	57122,00					

Prior to testing the above composition, many other compositions were tested: 5% CA+95% GSM, 15% CA+ 85% GSM and 20% CA + 80% GSM. But the results showed that these compositions are not optimal.

The figure 2.4. was composed based on the table 2.20. This graph shows that the test result line in between the minimum and maximum requirements lines. It shows that the composition 30% of CA and 70% of GSM is optimal.

Figure 2.2. Preparation for sieve analysis of GSM and CA

Figure 2.3. Sieve analysis of GSM and CA

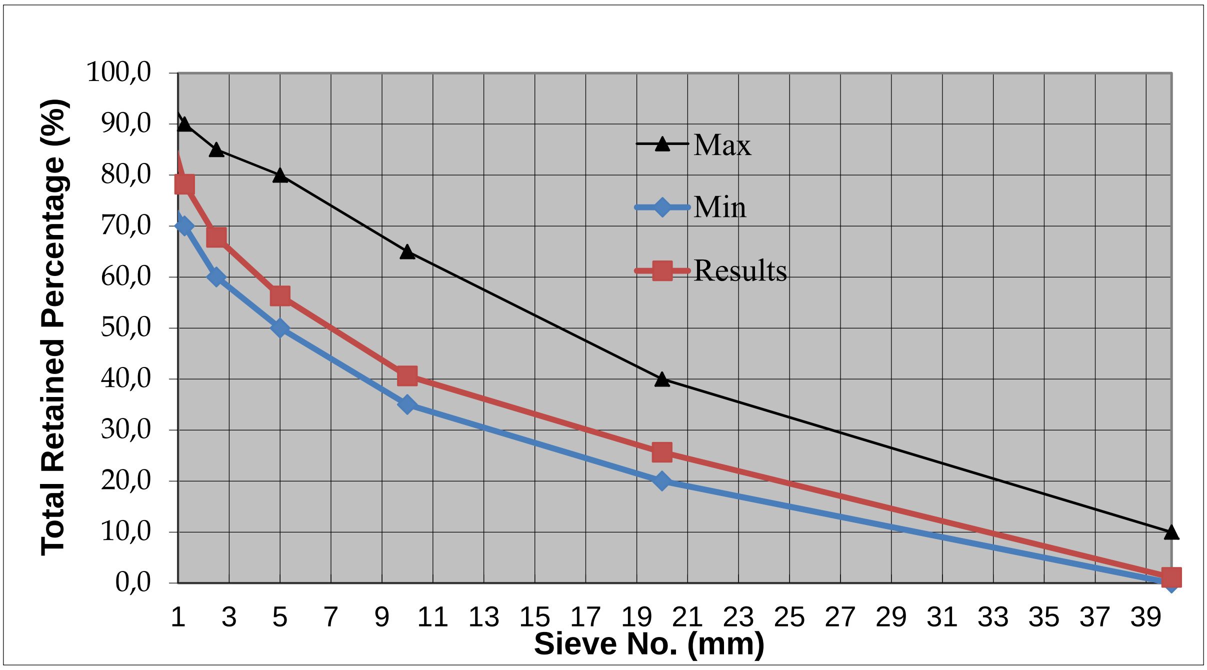


Figure 2.4. Sieve analysis results of GSM with CA

The main parameters to characterize CTB are the maximum dry density and the optimum moisture content (both obtained by means of the Modified Proctor test), the amount of cement and the minimum compressive strength. As the densities obtained vary as a function of the material/soil type (and other variables), instead of establishing a minimum density for cement-treated materials, in civil engineering, a percentage of the maximum dry density obtained with the Modified Proctor test is required. With the negative impact of moisture content and the positive impact of moisture content, the optimum moisture content (OMC) corresponding to the maximum dry density (MDD) is ideal for the preparation of cement treated base course. A compaction test is therefore undertaken as part of this study to determine the maximum modified dry density of the material in accordance with Test Method GOST 22733-2002. To determine the MDD and OMC, 6% cement (C) was added to the aggregates (30% CA +70% GSM). The results of the compaction test are shown in table 2.22.

Table 2.22

Maximum Dry Density and Optimum Moisture Content

PROCTOR COMPACTION TEST

Wt. Rammer	Ht. Drop	No.of Layers	No.of Blows	Wt. Mold(g)	Vol. Mold(cm³)
kg	mm		per layer	6570	981,25

Test No.		1	2	3	4	5	6
Wt.of Wet Soil + Mold	g	8570	8705	8815	8830	8770	8745
Wt.of Wet Soil	g	2000	2135	2245	2260	2200	2175
Wet Density	g/cm3	2,038	2,176	2,288	2,303	2,242	2,217
Container No.		1	2	3	4	5	6
Wt.of Wet Soil + Container	g	69,9	80,3	78,6	86,8	93,0	92,5
Wt.of Dry Soil + Container	g	68,1	77,1	75,2	82,1	86,7	85,0
Wt.of Container	g	22,2	21,7	31,54	31,28	30,8	26,1
Moisture Content	%	4,0	5,7	7,9	9,3	11,3	12,7
Dry Density	g/cm3	1,960	2,058	2,120	2,107	2,015	1,966

Maximum Dry Density (g/cm3)	2,120	Optimum Moisture Content (%)	7,9

The figure 2.5. was composed based on the table 2.21. This graph shows the OMC is 7.9% and MDD is 2.21 g/cm^3.

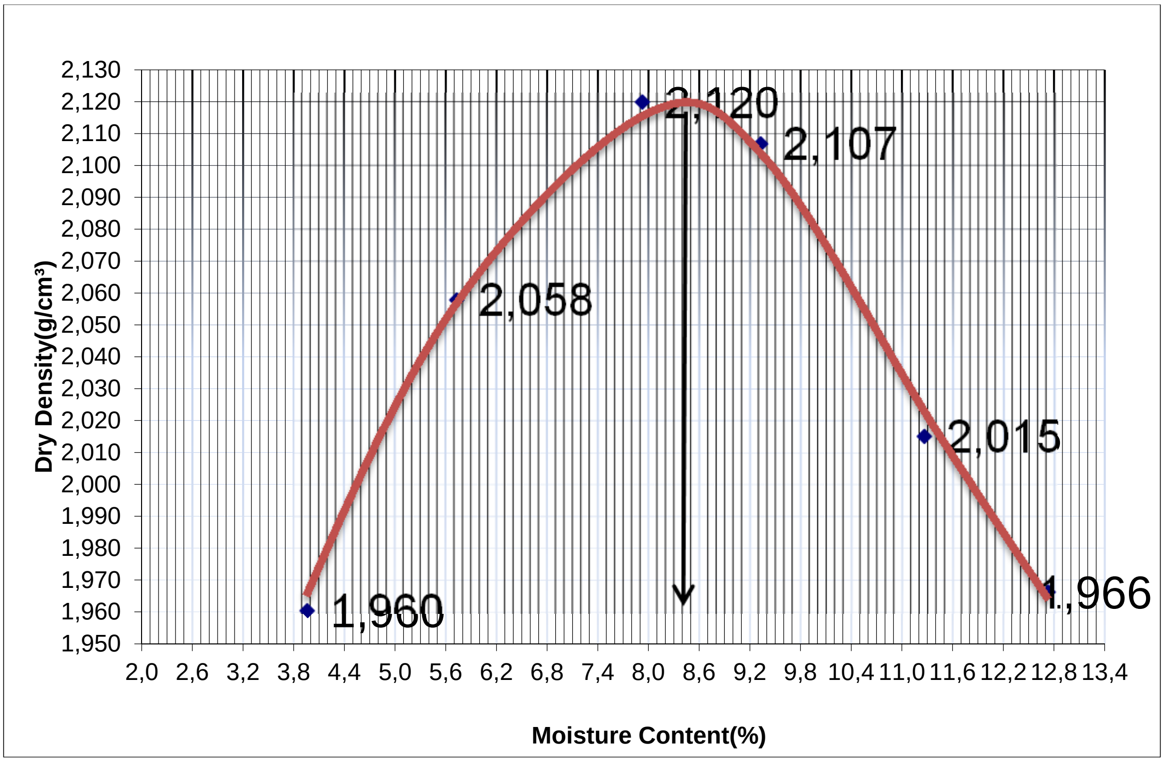


Figure 2.5. MDD and OMC test results

If the soil contains large particles, which were removed from the sample before testing, then to take into account the influence of their composition, the maximum density of dry soil is adjusted by the formula:

$$\rho'_{d\max} = \frac{\rho_{d\max}\rho_k}{\rho_k - 0{,}01K(\rho_k - \rho_{d\max})} \qquad (2.4)$$

$$w'_{opt} = 0{,}01 w_{opt}(100 - K) \qquad (2.5)$$

Corrected MMD=2.21 g/cm^3 and OMC=5.87 %. As seen from the compaction test results, little variability in maximum modified dry density can be observed from varying cement content, where density can be estimated to remain constant at 2.221t/m3.

However, the optimum moisture content corresponding to the tests show that the increasing cement content requires an increase in water content to achieve maximum compaction. This can be potentially explained with the conglomeration of fines, which affects the void ratio of the mix and the absorption of cement during the reaction process. Another explanation of this is that the free water available within the voids is consumed by the hydration process of cement. By interpolating the results from the compaction tests, the increase in OMC is approximately 0.18% for every 1% of cement as summarized in Table 2.23 below. This corresponds well with the minimum required water-cement ratio as discussed earlier in this section.

Table 2.23

Relationship between cement content and OMC

Cement Content	1	2	3	4	5	6
Optimum Moisture Content	4.92	5.11	5.28	5.47	5.65	5.87

Figure 2.6. Preparation for mix design

Procedure of Cement Treatment Base mix design

According to test results, MDD is 2221 kg/m^3. This means 1 m^3 consists of CA, GSM, and Cement.

Estimation of components:

(CA+GSM)+C= 2221kg/m^3 ; (CA+GSM)+ (CA+GSM)x0.06=2221kg/m^3 ;

1.06(CA+GSM)= 2221kg/m^3 ; (CA+GSM)=2095 kg/m^3 ;

CA=2095x0.3=628.5 kg/m^3; GSM=2095x0.7=1466.5 kg/m^3;

C= (CA+GSM) x0.06=126 kg/m^3; W=2221x0.0587=130.2 kg/m^3.

Estimated consumption of materials per 1 m3:

Crushed aggregate (CA) is 628.5 kg;

Gravel sand mix (GSM) is 1466.5 kg;

Cement (C) is 126.0 kg;

Water (W) is 130.2 kg.

Based on the results of mix design and according to the sub-clause 6.1 of GOST 23558-94, the specimens were prepared, cured 28 days and tested. A cubic of size 15 cm x 15 cm x 15 cm was prepared in order to determine the Compressive strength (figure 2.7 and 2.8). A prism of size 15 cm x 15 cm x 60 cm was prepared in order to determine the Flexural strength.

Figure 2.7. Test for Compressive strength

Figure 2.7. Tested sample

The flexural strength (FS) was determined by the four-point flexural beam test. By means of this test, the samples were broken in a central section of 15 cm x 15 cm x 15 cm, where the bending moment was considered to be constant. Hence, the failure was verified to be produced by exceeding the tensile strength of the weakest section in the lower side of the specimen. In total, 75 FS tests were performed. It must be pointed out that the dimensions of the used samples, the weight of the mold and the compaction density made the operations difficult with the samples since each one weighted around 50 kg. This value was reduced to 25 kg when the test was carried out due to the removal of the mold and the moisture lost during the curing time. Nevertheless, these dimensions of the specimens were necessary for the selected maximum aggregate size (40 mm) to fulfill the requirements of the local standards for manufactured CTB.

The tests were conducted in accordance with the GOST 10180-2012 "Concretes. Methods for strength determination using reference specimens". The results of the compressive strength tests are shown in table 2.24 and flexural strength in table 2.25.

Table 2.24

Test results of Compressive strength (with 6% cement)

Number of Specimen	Weight of specimen (g)	Density of specimens (g/sm^3)	Press result (KN)	Strength of concrete (kgf/sm^2)	Average strength (kgf/sm^2)
1	7690	2279	326,0	147,8	149,8
2	7720	2287	334,0	151,4	
3	7700	2281	338,2	153,3	
4	7715	2286	324,0	146,9	
5	7725	2289	280,6	127,2	
6	7710	2284	318,0	144,2	
7	7690	2279	354,0	160,5	
8	7695	2280	332,0	150,5	
9	7760	2299	344,0	155,9	
10	7680	2276	336,6	152,6	
11	7640	2264	334,8	151,8	
12	7715	2286	344,4	156,1	

Table 2.25

Test results of Flexural strength (with 6% cement)

Number of Specimen	Weight of specimen (g)	Density of specimens (g/sm^3)	Press result (KN)	Strength of concrete (MPa)	Average strength (MPa)
1	**2**	**3**	**4**	**5**	**6**
1	30778	2,280	13,0	1,73	
2	30800	2,281	13,8	1,84	
3	30774	2,280	13,4	1,79	

1	2	3	4	5	6
4	30778	2,280	11,0	1,47	
5	30810	2,282	12,8	1,71	
6	30790	2,281	14,0	1,87	
7	30798	2,281	13,6	1,81	
8	-	-	13,4	1,79	
9	-	-	13,0	1,73	
10	-	-	12,8	1,71	
11	-	-	13,2	1,76	
12	-	-	13,0	1,73	

The same tests as above were conducted with 5.5%, 5%, 4,5%, 4% and 3% of cement content. Consumption of materials per 1 m^3 for 5.5%, 5%, 4,5%, 4% and 3% cement content is shown in table 2.26.

Table 2.26

Consumption of materials per 1 m^3

Cement Content (%)	Crushed aggregate (kg)	Gravel Sand Mix (kg)	Water (kg)	Cement (kg)	Remarks
6%	628.5	1466.5	130.2	126.0	
5.5%	631.5	1473.5	128.0	115.7	
5%	634.5	1480.5	125.4	105.7	
4.5%	637.6	1487.7	123.5	95.6	
4%	640.6	1494.9	121.4	85.42	
3%	647.0	1501	117.2	65.0	

Compressive and flexural tests were prepared and conducted based on the above compositions. Summary of average test results are shown in table 2.27.

Table 2.27

Summary of average test results

Cement content	Average Compressive strength (kgf/cm^2)	Average Flexural strength (Mpa)	Curing days
6.0%	149.8	1.74	28-days
5.5%	134.7	1.60	28-days
5.0%	114.7	1.42	28-days
4.5%	93.2	1.07	28-days
4%	80.4	0.89	28-days
3%	51.1	0.62	28-days

To analyze the frost resistance of CTB were conducted tests in accordance with GOST 10060-2012. The results of frost resistance of CTB are shown in table 2.28.

Table 2.27

Test results of frost resistance

Measured value	Standard requirements	Test results	Remarks
1	**2**	**3**	**4**
Frost resistance grade by appearance of the main samples after testing	Cracks, chips and peeling of ribs are not allowed	No (missing)	Missing
Frost resistance grade by loss of weight of the main samples	Loss of weight of samples shall not exceed 2%	Decrease in samples weight (after 25 cycles) From 0.52% to 1.3%	Conforms to F-25

1	2	3	4
Frost resistance grade by loss of strength in MPa	The samples are consider to pass the testing of frost resistance of the proportion $M_{min}{}^{II} \geq 0.9\ xM_{min}{}^{I}$ is kept	$0.9\ x\ M_{min}{}^{I}=16.5$ $M_{min}{}^{II}= 17.9$	Conforms to F-25

The samples have passed 25 cycles by the first method under temperature (18±2) ^oC, which conforms to the frost resistance grade F 25.

Conclusions on the CHAPTER II

Conclusion of the chapter 2nd summarized as follow:

- CTB manufactured in situ is a sustainable road construction technique that adds cement and water to the GSM or material placed on or near the road to improve its characteristics, achieving a more resistant material. A higher proportion of cement would give greater resistance in the long term but would increase the probability of cracking failure. Therefore, the amount of cement is usually limited to the one that guarantees the minimum value of the CS;
- This research was carried out for a GSM and crushed aggregate with a maximum aggregate size of 40 mm, without organic materials and soluble sulfate. Gravel sand mix and crushed aggregate were tested according to the GOST 8267 and GOST8736. The test result shows the materials meet the requirements of GOST 23558. Cement was tested in accordance with requirements of GOST 22266;
- For the determination of dosages, each material conducted maximum dry density and optimum moisture content tests according to the GOST 22733. Six types of mix design were calculated using the above test results;
- Cement was added between 3% to 6% and water 5% to 6%. With these values, a maximum dry density of 2.21 g/cm3 was obtained and CS at 28-days was 160 kgf/cm2 – 44 kgf/cm2;
- For establishing these correlations, 75 prismatic samples of 15 cm x 15 cm x 60 cm were manufactured and were tested in the four-point beam test for determining the FS. In total, over 150 samples were tested for the CS and FS.

CHAPTER III. RECOMMENDATION OF RATIO BETWEEN COMPRESSIVE AND FLEXURAL STRENGTH ON CTB

3.1 Mathematic Statistics and data analysis

An experimental data processing was carried out to determine the interrelation between compressive strength and flexural strength.

Correlation analysis shows the degree of connection between two variables, x and y. In our case, X_i is compressive strength test results and Y_i is flexural strength test results, which are shown in the Table 3.1

Table 3.1

Experimental data

No.1	X_i	Y_i	$\bar{X}$	$\bar{Y}$	$\overline{XY}$	X_i^2	Y_i^2
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1	147,79	17,68	102,96	12,68	2612,87	21840,90	312,58
2	151,41	18,77	102,96	12,68	2841,73	22926,00	352,24
3	153,32	18,22	102,96	12,68	2794,06	23506,20	332,11
4	146,88	14,96	102,96	12,68	2197,32	21573,73	223,80
5	127,21	17,41	102,96	12,68	2214,39	16181,20	303,04
6	144,16	19,04	102,96	12,68	2744,81	20782,11	362,52
7	160,48	18,50	102,96	12,68	2968,24	25753,83	342,10
8	150,51	18,22	102,96	12,68	2742,83	22652,26	332,11
9	155,95	17,68	102,96	12,68	2757,14	24319,36	312,58
10	152,59	17,41	102,96	12,68	2656,32	23284,32	303,04
11	151,78	17,95	102,96	12,68	2724,68	23035,95	322,27
12	156,13	17,68	102,96	12,68	2760,34	24375,95	312,58
13	133,73	17,14	102,96	12,68	2291,65	17884,60	293,64
14	134,19	17,68	102,96	12,68	2372,42	18006,06	312,58
15	134,46	17,41	102,96	12,68	2340,66	18079,13	303,04
16	128,11	17,14	102,96	12,68	2195,33	16412,68	293,64
17	138,81	12,24	102,96	12,68	1699,04	19268,40	149,82
18	138,18	15,78	102,96	12,68	2179,86	19092,61	248,88
19	134,46	17,41	102,96	12,68	2340,66	18079,13	303,04
20	134,19	17,14	102,96	12,68	2299,42	18006,06	293,64
21	133,55	15,50	102,96	12,68	2070,59	17836,14	240,37

1	2	3	4	5	6	7	8
22	129,11	16,59	102,96	12,68	2142,18	16669,22	275,29
23	143,16	16,05	102,96	12,68	2297,47	20495,55	257,54
24	113,33	13,87	102,96	12,68	1572,16	12844,44	192,43
25	49,87	15,50	102,96	12,68	773,13	2486,68	240,37
26	126,03	17,14	102,96	12,68	2159,59	15882,72	293,64
27	126,93	15,78	102,96	12,68	2002,50	16112,07	248,88
28	108,80	14,14	102,96	12,68	1538,87	11837,44	200,05
29	90,67	13,60	102,96	12,68	1233,07	8220,44	184,96
30	116,96	14,69	102,96	12,68	1717,91	13679,64	215,74
31	117,87	13,87	102,96	12,68	1635,05	13892,55	192,43
32	116,05	13,60	102,96	12,68	1578,33	13468,38	184,96
33	115,15	13,33	102,96	12,68	1534,67	13258,75	177,64
34	112,43	13,33	102,96	12,68	1498,42	12639,76	177,64
35	119,68	14,42	102,96	12,68	1725,31	14323,30	207,82
36	116,96	14,96	102,96	12,68	1749,72	13679,64	223,80
37	117,87	16,59	102,96	12,68	1955,64	13892,55	275,29
38	118,77	11,97	102,96	12,68	1421,48	14107,10	143,23
39	124,21	15,23	102,96	12,68	1892,02	15428,95	232,01
40	122,40	14,14	102,96	12,68	1731,23	14981,76	200,05
41	125,12	14,69	102,96	12,68	1837,76	15655,01	215,74
42	88,85	12,51	102,96	12,68	1111,73	7894,91	156,55
43	81,60	10,34	102,96	12,68	843,42	6658,56	106,83
44	83,41	9,25	102,96	12,68	771,41	6957,78	85,53
45	79,79	11,70	102,96	12,68	933,18	6365,91	136,80
46	68,00	9,79	102,96	12,68	665,86	4624,00	95,88
47	85,23	10,61	102,96	12,68	904,08	7263,58	112,53
48	81,69	10,88	102,96	12,68	888,79	6673,37	118,37
49	80,06	10,61	102,96	12,68	849,26	6409,39	112,53
50	77,43	10,06	102,96	12,68	779,25	5995,30	101,28
51	76,16	14,69	102,96	12,68	1118,64	5800,35	215,74
52	76,43	9,25	102,96	12,68	706,84	5841,85	85,53
53	86,31	11,15	102,96	12,68	962,58	7450,22	124,37
54	88,85	9,25	102,96	12,68	821,72	7894,91	85,53
55	81,60	9,52	102,96	12,68	776,83	6658,56	90,63
56	83,41	8,70	102,96	12,68	726,03	6957,78	75,76

1	2	3	4	5	6	7	8
57	79,79	9,25	102,96	12,68	737,87	6365,91	85,53
58	68,00	5,44	102,96	12,68	369,92	4624,00	29,59
59	85,23	9,52	102,96	12,68	811,36	7263,58	90,63
60	81,69	9,79	102,96	12,68	799,92	6673,37	95,88
61	80,06	9,52	102,96	12,68	762,16	6409,39	90,63
62	77,43	7,89	102,96	12,68	610,76	5995,30	62,22
63	76,16	8,16	102,96	12,68	621,47	5800,35	66,59
64	76,43	9,25	102,96	12,68	706,84	5841,85	85,53
65	54,49	6,80	102,96	12,68	370,54	2969,23	46,24
66	45,33	6,53	102,96	12,68	295,94	2055,11	42,61
67	38,99	4,08	102,96	12,68	159,07	1519,96	16,65
68	63,47	5,98	102,96	12,68	379,78	4028,02	35,81
69	53,49	6,26	102,96	12,68	334,65	2861,54	39,14
70	48,42	7,07	102,96	12,68	342,40	2344,11	50,01
71	49,96	6,80	102,96	12,68	339,71	2495,74	46,24
72	53,49	6,53	102,96	12,68	349,20	2861,54	42,61
73	52,86	5,44	102,96	12,68	287,55	2794,04	29,59
74	53,77	7,34	102,96	12,68	394,85	2890,71	53,93
75	44,79	6,26	102,96	12,68	280,20	2006,08	39,14

Determine mean of dataset

$$\bar{X} = \frac{\sum X_i}{n} = \frac{7721.90}{75} = 102.96;$$

$$\bar{Y} = \frac{\sum Y_i}{n} = \frac{950.64}{75} = 12.68$$

$$\overline{XY} = \frac{\sum X_i Y_i}{n} = \frac{107614.68}{75} = 1434.86$$

Determine variance

$$D(x) = \frac{\sum X_i^2}{n} - \bar{X}^2 = \frac{883698.93}{75} - 10600.48 = 1182.17$$

$$D(y) = \frac{\sum Y_i^2}{n} - \bar{Y}^2 = \frac{13341.61}{75} - 160,66 = 17.23$$

Determine standard deviation of dataset

$$\sigma(x) = \sqrt{D(x)} = \sqrt{1182.17} = 34.38$$

$$\sigma(y) = \sqrt{D(y)} = \sqrt{17.23} = 4.15$$

Determine correlation coefficient

$$\mathrm{r_{xy}} = \frac{\overline{\mathrm{x} * \mathrm{y}} - \bar{\mathrm{x}} * \bar{\mathrm{y}}}{\sigma(\mathrm{x}) * \sigma(\mathrm{y})} = \frac{1434.86 - 102.96 * 12.68}{34.38 * 4.15} = 0.91$$

Determine regression equation

$$\mathrm{Y_x} = \mathrm{r_{xy}} \frac{\mathrm{x} - \bar{\mathrm{x}}}{\sigma(\mathrm{x})} \sigma(\mathrm{y}) + \bar{\mathrm{y}} = 0.91 \frac{\mathrm{X} - 102.96}{34.38} * 4.15 + 12.68$$

$$= 0,11(\mathrm{X} - 102.96) + 12.68 = 0.11\mathrm{X} + 1.36$$

$$\mathbf{Y_x = 0.11X + 1.36}$$

Determine regression coefficient

k = a = 0.11

Determination factor

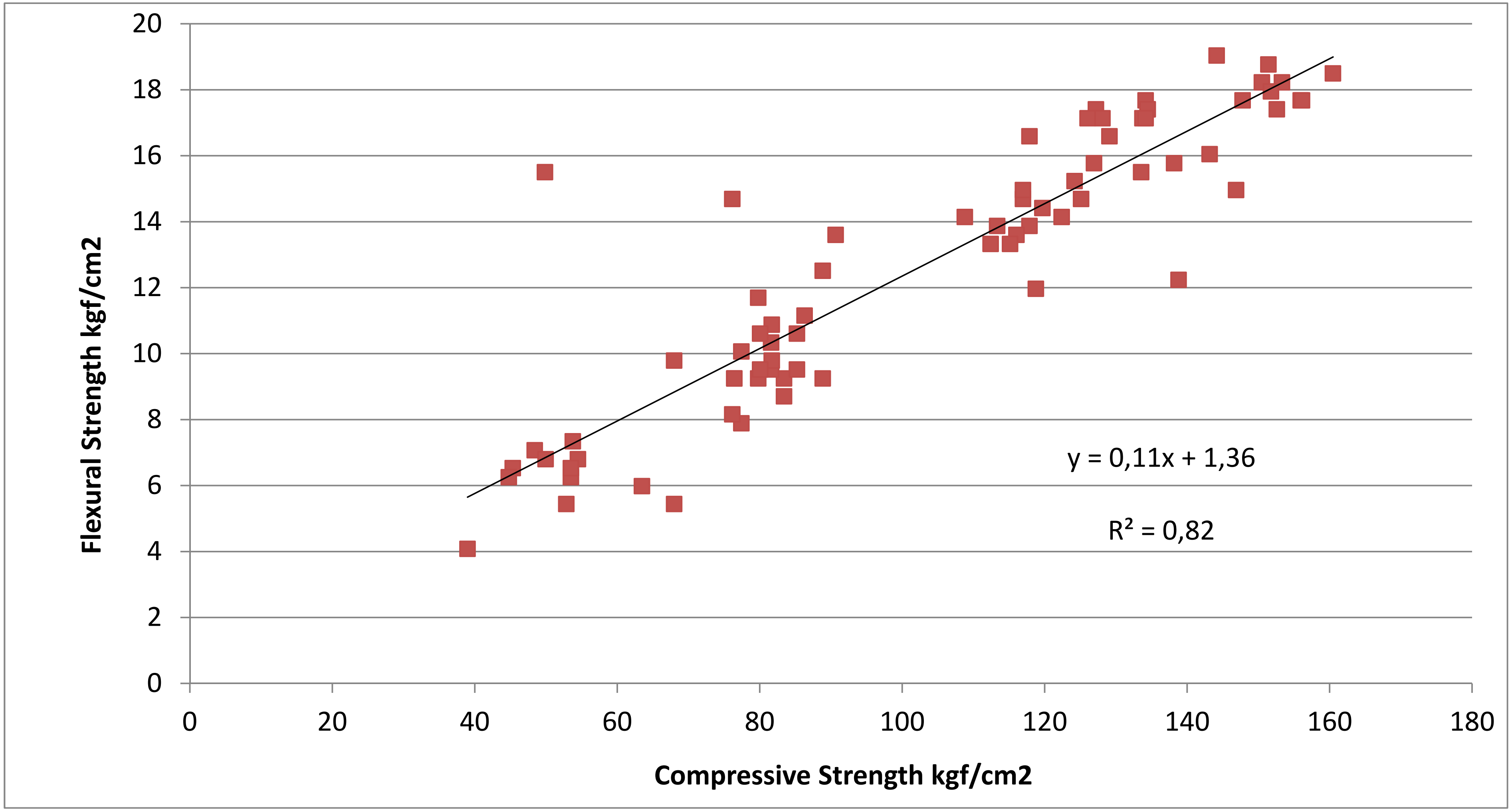
$R^2 = 0.91^2 = 0.82$

The correlation coefficient is 0.91. Thereupon correlation rate is high.

The graph 3.1 was prepared based on the above test results and data processing.

According to the results of above experimental data processing, the Equation 3.1 can model the relationship between the CS and FS.

FS=0.11xCS+1.36 (3.1)



Graph 3.1. Relationship between Compressive and Flexural strength

3.2 Recommended technical requirements for CTB

According to the research results, we recommend the following criteria for Cement Treatment Base (CTB):

For the mark M10 strength the Compressive Strength (CS) is 10 kgf/cm2 and Flexural strength (FS) is according to the results of mix design tests;

- M20 Compressive Strength (CS) is 20 kgf/cm2 and Flexural strength (FS) is according to the results of mix design tests;
- M30 Compressive Strength (CS) is 30 kgf/cm2 and Flexural strength (FS) is according to the results of mix design tests;
- M40 Compressive Strength (CS) is 40 kgf/cm2 and Flexural strength (FS) is according to the results of mix design tests;

On the marks M10, M20, M30 and M40 the cement content is very little and therefore, preparation (making) of sample for the FS (15X15X60) is very difficult. In addition, with little content of cement, it is easy to damage (break) the sample during preparation, transportation or testing. A large human factor aspect is shown for these marks of FS. Thus, we recommend the compliance of the above FS marks with the requirements shall not be required or be according to the results of mix design.

- M60 Compressive Strength (CS) is 60 kgf/cm2 and Flexural strength (FS) is 7 kgf/cm2;
- M75 Compressive Strength (CS) is 75 kgf/cm2 and Flexural strength (FS) is 9 kgf/cm2;
- M100 Compressive Strength (CS) is 75 kgf/cm2 and Flexural strength (FS) is 12 kgf/cm2;

Literature abroad research and some international standards show that for CTB from 4% to 14% cement adding are rational. Thus, we recommend CTB marks increase up to M200. However, during the construction of CTB the SHNK 2.05.02-07's requirements shall be fulfilled.

In accordance with sub-clause 7.12 of “In bases of concrete class B12.5 and above, it is necessary to provide for longitudinal and transverse compression and expansion joints” So, according to the results of the research, we propose the following requirements table, which shows the relationship between marks of CS and FS (table 3.2):

Table 3.2

Proposed requirements

Mark for strength	**Compressive strength, (kgf/cm2)**	**Flexural strength, (kgf/cm2)**	**Mark for strength**	**Compressive strength, (kgf/cm2)**	**Flexural strength, (kgf/cm2)**
M10	1,0 (10)	0,2 (2)	M10	1,0 (10)	Acc. Mix design
M20	2,0 (20)	0,4 (4)	M20	2,0 (20)	Acc. Mix design
M40	4,0 (40)	0,8 (8)	M40	4,0 (40)	Acc. Mix design
M60	6,0 (60)	1,2 (12)	M60	6,0 (60)	0,7 (7)
M75	7,5 (75)	1,5 (15)	M75	7,5 (75)	0,9 (9)
M100	10,0 (100)	2,0 (20)	M100	10,0 (100)	1,2 (12)
-	-	-	M120	12 (120)	1,4 (14)
-	-	-	M150	15 (150)	1,8 (18)
-	-	-	M180	18 (180)	2,0 (20)
-	-	-	M200	20 (200)	2,3 (23)

3.3 Recommendations for adjustment of payment considering the strength results and thickness of a layer

According to the sub-clause 6.40 of SHNK 3.06.03-08 "In order to control the strength, the mixture is sampled and three samples of 250 m3 are taken. A deviation from the required strength indicators is permitted as follows:

- In the preparation of mixtures in quarry mixing plants – not more than ± 8%;
- In the preparation of mixtures by a single-pass soil mixing machine – not more than ± 15%;
- In the preparation of mixtures by road harrow — not more than ± 25%." [15].

However, there is no information or requirements regarding adjustment of payments based on strength characteristics or compaction ratio.

Based on the results of research and study of foreign practice, we recommend the following criteria for Cement Treatment Base (CTB):

Adjustment of payment based on CS and FS results

The strength level of CTB will be considered satisfactory if the averages of all sets of minimum three [3] consecutive strength test results equal or exceed the specified strength, and no individual strength test result is deficient by more than 15% of the specified strength.

CTB deemed to be not acceptable using the above criteria may be rejected unless the Contractor can provide evidence, by means of core tests, that the quality of CTB represented by failed test results is acceptable in place. At least three representative cores shall be taken from each member or area of CTB in place that is considered deficient. The location of cores shall be determined by the Supervisor/Engineer so that there will be at least impairment of strength of the structure. The obtaining and testing of drilled cores shall be in accordance with local standards.

CTB in the area represented by the cores will be considered adequate if the average strength of the cores is equal to at least 85% of, and if no single core is less than 75% of, the specified strength.

If the strength of control specimens does not meet the requirements of standards/design, and it is not feasible or not advisable to obtain cores from the structure due to structural considerations, payment of the CTB shall be made at an adjusted price due to strength deficiency of CTB specimens as specified hereunder (table 3.3):

Table 3.3

Price adjustment

Deficiency in the strength of CTB specimens, percent (%)	Percent (%) of contact or bill of quantity price allowed
Less than 5	100%
5 to less than 10	85%
10 to less than 15	75%
15 to less than 20	65%
20 to less than 25	Remove and replace or 50%
25 or more	Remove and replace

Adjustment of payment based on CTB thickness

When the measurement of any core is less than the specified thickness by more than 25 mm, the actual thickness of the CTB in this area shall be determined by taking additional cores at no less than 5 m intervals parallel to the center line in each direction from the affected location until a core is found in each direction, which is not deficient in thickness by more than 25mm. The thickness of the remained of the segment to be used to get the average thickness of each lot shall be determined by taking the average thickness of additional cores which are not deficient by more than 25 mm.

When the average thickness of the CTB per lot is deficient, payment for the lot shall be adjusted as follow (table 3.4):

Table 3.4

Adjustment for thickness

Deficiency in the average thickness per lot (mm)	Percent (%) of contact or bill of quantity price per lot
0 - 5	100%
6 - 10	95%
11- 15	85%
16 - 20	70%
21- 25	Remove and replace or 50%
More than 25	Remove and replace

3.4 Evaluation of the effectiveness of research results

During active cement hydration in the days following compaction, CTB layers are prone to transverse shrinkage cracking, which is often later manifest as reflective cracking in the wearing course. These cracks are initially a cosmetic problem but, if wide enough, may allow water to infiltrate and weaken the pavement. Autogenously shrinkage occurs in the CTB due to self-desiccation during cement hydration, and drying shrinkage occurs as a result of water evaporation into the surrounding environment. High-severity shrinkage has been linked to many factors, including high fines content, poor compaction, excessive compaction moisture, inadequate moist curing, and high cement content.

After cement hydration is substantially complete and the layer is in service, the governing CTB failure mechanisms are dependent on the layer stiffness. Bases with a higher cement content and therefore higher stiffness behave as rigid systems, capable of bearing traffic loads and evenly distributing these loads to the subgrade. The primary failure in these cases is the widening of shrinkage cracks due to thermal cycling and load-induced degradation around these cracks. Load-induced fatigue cracking may also occur if the layer is too thin. As the cement content and stiffness decrease, the base begins to behave more as a flexible system. Though transverse and fatigue cracking is still a concern, other failure types begin to govern performance. Once the CTB is significantly distressed, further deterioration associated with water infiltration can occur. Under trafficking, fines can be pumped out of the layer, leaving only coarser aggregate in the base. The removal of fines results in decreased aggregate interlock, causing poor load transfer and additional structural deterioration. The end result of CTB failure is increased pavement roughness and unacceptable ride quality.

The proper design of CTB is a balance between achieving suitable strength and durability and minimizing the risks of shrinkage cracking. In the past, the mindset "stronger is better" often governed design, so cement contents around 6 to 8 percent were frequently used [3].

According to the sub-clause 4.1.1 of GOST 23558-94, the required compressive strength for the mark M75 is 75 kgf/cm^2 and flexural strength is 15 kgf/cm^2. But, in practice for achieving flexural strength of 15 kgf/cm^2, the CTB compressive strength shall be around 120 kgf/cm^2 ~ 130 kgf/cm^2. This means to achieve the required flexural strength, input/adding of more cement content is required. However, as previously discussed, these high cement contents can lead to excessive shrinkage cracking and poor pavement performance. Many researchers, therefore, recommend limiting the cement content or design strength to minimize shrinkage.

In order to achieve the mark M75, we recommend establishing the compressive strength 75 kgf/cm^2 and flexural strength 9 kgf/cm^2. This requirement will ensure that the required strength with optimum cement content is met. So, to achieve the compressive strength of 120 kgf/cm^2 ~ 130 kgf/cm^2, 115 kg to 120 kg of cement is required for 1m^3 of CTB. To achieve the compressive strength of 75 kgf/cm^2, 80 kg to 85 kg of cement is required for 1m^3 of CTB. As a result, an average of 35 kg of cement is saved per 1m^3 of CTB. If the thickness of CTB is 20 cm, 23 000 m^3 of CTB material (0,2x11,5x1000=23 000 m^3) will be required for 1 km of the 1st category road with 11,5 m wide lane. In total, 805 000 kg (23000x35=805 000) of cement will be saved per each 1 km of road. Considering that 1 kg of cement costs 700 UZB SUM including transportation, 563 500 000 UZB SUM will be saved per each 1 km of road.

Conclusions on the CHAPTER III

From the above results, the following conclusions can be obtained:
- the relationship between the CS and FS was determined with the 28-day samples. Using the above equation, the FS 28-days test results can be estimated from the values of the CS. The results show that the local standard specifications are required to be modified. Especially for the requirements of CS and FS;
- Also, in local standards there is no information or requirements regarding the adjustment of payments based on strength characteristics or compaction ratio and thickness of CTB. For solving this matter price adjustment is proposed based on strength and thickness deficiency of CTB;
- It was found that using the research results 563 500 000 UZB SUM can be saved per each 1 km road. In additional, high-severity shrinkage has been linked to many factors, one of the factors is high cement content. High cement contents can lead to excessive shrinkage cracking and poor pavement performance. Many researchers, therefore, recommend limiting the cement content or design strength to minimize shrinkage cracking. Using the research results equation during CTB design (supervision and construction) allows minimizing the cement content of CTB and shrinkage cracking.

Results Obtained and General Conclusions

General conclusion summarized as follow:

- pavements with Cement Treatment Base will be much stronger and more rigid than an unsterilized, granular base. Cement Treatment Base thicknesses are less than those required for granular bases carrying the same traffic. It can distribute loads over a wider area, reducing the stresses on the subgrade and acting as the load-carrying element of flexible pavement or a sub-base for concrete. Nowadays, Cement Treatment Base is used almost for the whole Uzbek National Highway;
- As mentioned-above, Uzbekistan is performing many road constructions works based on international biddings. At the same time, many large international construction companies are working in Uzbekistan. This calls for a revision of our national standards.
- During the literature review, no studies were found on the relationship between compressive strength and flexural strength. These two characteristics are the most important data for quality control and quality assurance.
- To determine the relationship between CS and FS, many tests were carried out on GSM, crushed aggregate, cement and water.
- In total, over 150 samples were tested for establishing these correlations.
- The relationship between the CS and FS was determined with the 28-day samples. Using the above equation, the FS 28-days test results can be estimated from the values of the CS. The results show that the local standard specifications are required to be modified. Especially for the requirements of CS and FS.
- In local standards there is no information or regalements regarding the adjustment of payments based on strength characteristics or compaction ratio and thickness of CTB. For solving this matter price adjustment is proposed based on strength and thickness deficiency of CTB.
- It was found that using the research results 563 500 000 UZB SUM can be saved per each 1 km road. In additional, using the research results equation

during CTB design (supervision and construction) allows minimizing the cement content of CTB and shrinkage cracking.

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Appendix

ABBREVIATIONS

AASHTO	American Association of State Highway and Transportation Officials
ASTM	American Standard of Testing and Materials
GOST	Local Standard (state standard*)*
IKN	Local Department Standards and Rules
QA	Quality Assurance
QC	Quality Control
ShNK	Local Urban Planning Standards and Rules
CTB	Cement Treatment Base
O’zDSt	Uzbekistan National Standard
GSM	Gravel Sand Mix
CA	Crushed Aggregate
CS	Compressive Strength
FS	Flexural Strength
OMC	Optimum Moisture Content
MDD	Maximum Dry Density

Тошкент автомобиль йўлларини лойиҳалаш, қуриш ва эксплуатацияси институти магистратура бўлими 524-17 гуруҳ магистранти Юсупалиев Умид Ғаниевичга

Тавсифнома

Юсупалиев Умид Ғаниевич 1988 йил 7 июнда Фарғона вилояти Қўқон шахрида ишчи оиласида туғилган. 2017-2019 ўқув йилларида Тошкент автомобиль йўлларини лойиҳалаш, қуриш ва эксплуатацияси институти магистратура бўлими 5А341401-автомобиль йўлларини лойиҳалаш ва қуриш мутахасисслиги 524-17 гуруҳида таҳсил олди.

У.Ғ. Юсупалиев “Автомобиль йўлларини қуриш ва эксплуатация қилиш” кафедрасининг топшириғига асосан “Автомобиль йўллари асоси учун цемент билан ишлов берилган чақиқтош-қум қоришмаларининг мустаҳкамлик кўрсаткичларини ошириш” мавзусида магистирлик диссертация ишини таёрлади.

У.Ғ. Юсупалиев магистирлик ишини бажариш ва ўқув йиллари давомида ўзининг билимга чанқоқлиги, тиришқоқлиги билан талабалар орасида ажралиб турди. У дарсларга ўз вақтида қатнашди ва институт томонидан ўтказилган барча тадбирларга ҳамда жамоат ишларида фаол иштрок этиб келган.

Юсупалиев Умид Ғаниевич Ўзбекистон Республикасининг ривожланиши йўлида бор куч ва иқтидорини намоён этади ҳамда етук мутаҳассис, ватанпарвар бўлиб ўз олдига қўйилган мақсад ва вазифаларни шараф билан адо этишига ишонч билдираман.

MAGISTRATURA BO'LIMI

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Илмий раҳбар **Т.Ж. Амиров**

5А341401-Автомобиль йўлларини лойиҳалаш ва қуриш мутахасисслиги бўйича магистрлик мақомини олиш учун Юсупалиев Умид Ғаниевичнинг “Автомобиль йўллари асоси учун цемент билан ишлов берилган чақиқтош-қум қоришмаларининг мустаҳкамлик кўрсаткичларини ошириш” мавзусида бажарган диссертация ишига берилган

Хулоса

Юсупалиев Умиднинг илмий тадқиқот ишида автомобиль йўллари асоси учун цемент билан ишлов берилган чақиқтош-қум қоришмаларининг мустаҳкамлик кўрсаткичлари орасидаги боғлиқликни лаборатория синовлари асосида аниқлашни ва маҳаллий материалларга оптимал миқдорда чақиқтош қўшиб қоришмаларнинг мустаҳкамлик кўрсаткичларини оширишни ўз олдига мақсад қилиб қўйган.

Тадқиқотнинг долзарблиги автомобиль йўллари учун ишлатиладиган цемент билан ишлов берилган чақиқтош-қум қоришмаларига қўйиладиган талабларнинг ўзаро мутаносиб эмаслиги муаммосини ҳал қилади. Шу билан биргаликда хорижий давлатларнинг тажрибаларини ва баъзи техник регламентларини миллий норматив ҳужжатлар билан таққослаб тахлил қилинган. Диссертация ишида ўндан ортиқ хорижий давлатларда бажарилган илмий тадқиқот ишлари тахлил қилиб ўрганилган.

Тадқиқотнинг илмий янгилиги автомобиль йўллари учун цемент билан ишлов берилган чақиқтош-қум қоришмаларининг сиқилишдаги мустаҳкамлиги ва эгилишдаги чўзилишга мустаҳкамлиги орасидаги боғлиқлик аниқланиб уни қўллашга тавсиялар ишлаб чиқилган. Шу билан биргаликда ишлаб чиқаришдаги мавжуд муаммоли вазиятларни бартараф қилиш мақсадида чет мамлакатларнинг тажрибаларидан фойдаланиб миллий норматив хужжатларга қўшимчалар киритиш бўйича тавсиялар ишлаб чиқилган.

Илмий тадқиқот ишининг ёзув қисми олинган натижалар асосида келтирилган жадваллар ва графиклар билан ифодаланган. Барча хулосалар ва иловалар аниқ рақамлар ва далил билан келтирилган.

Юсупалиев Умид ўз тадқиқот ишида қўйилган вазифаларни мустақил равишда бажарди. Унинг бу иши автомобиль йўлларини лойиҳалаш ва қурилишида қўлланилиши мумкин.

Ушбу илмий тадқиқод иши магистрлик диссертациясига қўйилган талабларга мос келади. Магистрант Юсупалиев Умид Ғаниевич 5А341401-Автомобиль йўлларини лойиҳалаш ва қуриш мутахасисслиги бўйича магистрлик даражасини олишга муносиб деб хисоблайман, унинг бажарган ишини ижобий баҳолайман.

Илмий раҳбар: **(PhD) Т.Ж. Амиров**

Тошкент автомобиль йўлларини лойиҳалаш қуриш ва эксплуатацияси институтининг 5А341401-“Автомобиль йўлларини лойиҳалаш ва қуриш” мутахасисслиги бўйича магистр Юсупалиев Умид Ғаниевичнинг “Автомобиль йўллари асоси учун цемент билан ишлов берилган чақиқтош-қум қоришмаларининг мустаҳкамлик кўрсаткичларини ошириш” мавзусида бажарган диссертация ишига берилган

ТАҚРИЗ

Бугунги кунда Ўзбекистон миллий автомагистралини қуришда ва бошқа халқаро тендендерлар асосида қурилаётган автомобиль йўлларида цемент билан ишлов берилган чақиқтош-қум қоришмаларининг мустаҳкамлик кўрсаткичларини ошириш долзарб вазифалардан ҳисобланади

Юсупалиев Умиднинг илмий тадқиқот иши автомобиль йўллари асоси учун цемент билан ишлов берилган чақиқтош-қум қоришмаларининг мустаҳкамлик кўрсаткичлари орасидаги боғлиқликни лаборатория синовлари асосида аниқлашга қаратилган.

Ушбу илмий тадқиқот ишида цемент билан ишлов берилган чақиқтош-қум қоришмаларининг мавжуд қуриш усуллари ва замонавий технологиялар, хориж давлатлари технологиялари келтириб ўтилган. Илмий тадқиқод ишида ривожланган чет давлатларининг “American Assocation of State Highway and Transportation Official” (AASHTO), American Society for Testing and Materials” (ASTM), “British Standard” (BS) каби норматив хужатлари ва уларнинг талаблари ҳам инобатга олинган. Шу билан биргаликда цемент билан ишлов берилган чақиқтош-қум қоришмаларининг сиқилишдаги мустаҳкамлиги ва эгилишдаги чўзилишга мустаҳкамлиги орасидаги боғлиқлик аниқланиб қўллашга тавсиялар ишлаб чиқилган.

Магистрлик диссертацияси кириш, учта боб, умумий хулоса, фойдаланилган адабиётлар рўйхатидан иборат.

Юсупалиев Умид илмий тадқиқот ишини бажаришда, ўз олдига мақсад ва вазифаларини аниқ белгилаб олган. Ушбу вазифалар бўйича лаборатория синовларини олиб борган.

Бу илмий тадқиқот иши автомобиль йўлларини лойиҳалашда ва қуришда муҳим ахамиятга эга.

Магистрлик диссертациясида қуйидаги камчиликлар учрайди:

- боболар бўйича олинган хулосаларни янада аниқроқ ва кенгроқ акс эттирганда мақсадга мувофиқ бўлар эди;
- диссертацияда цемент билан ишлов берилган чақиқтош-қум қоришмаларининг, қуриш технологик жараёни келтирилса ўринли бўлар эди.

Ушбу диссертация иши магистрлик диссертациясига қўйилган талабларга мос келади. Магистрант Юсупалиев Умид Ғаниевич 5А341401-“Автомобиль йўлларини лойиҳалаш ва қуриш мутахасисслиги бўйича” магистрлик даражасини олишга муносиб деб хисоблайман ва ҳимояга тавсия этаман.

“АЙҚ ва Л” кафедраси
мудири, (PhD) **Р.М.Худайқулов**

IMZOSINI TASDIQLAYMAN
TAYLQEI
XODIMLAR BO'LIMI BOSHLIG'I

O'ZBEKISTON RESPUBLIKASI AVTOMOBIL YO'LLARI DAVLAT QO'MITASI * TOSHKENT AVTOMOBIL YO'LLARINI LOYIHALASH, QURISH VA EKSPLUATATSIYASI INSTITUTI *
XODIMLAR BO'LIMI

5А341401-Автомобиль йўлларини лойиҳалаш ва қуриш мутахасисслиги бўйича магистрлик мақомини олиш учун Юсупалиев Умид Ғаниевичнинг “Автомобиль йўллари асоси учун цемент билан ишлов берилган чақиқтош-қум қоришмаларининг мустаҳкамлик кўрсаткичларини ошириш” мавзусида бажарган диссертация ишига берилган

ТАҚРИЗ

Юсупалиев Умиднинг илмий тадқиқот иши автомобиль йўллари асоси учун цемент билан ишлов берилган чақиқтош-қум қоришмаларининг мустаҳкамлик кўрсаткичлари орасидаги боғлиқликни лаборатория синовлари асосида аниқлашга қаратилган.

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Магистрлик диссертацияси кириш, учта бўлим, умумий хулоса, фойдаланилган адабиётлар рўйхатидан иборат.

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Бу илмий тадқиқот иши автомобиль йўлларини қуришда муҳим ахамиятга эга.

Магистрлик диссертациясида қуйидаги камчиликлар учрайди:

- боболар бўйича олинган хулосаларни янада аниқроқ ва кенгроқ акс эттирганда мақсадга мувофиқ бўлар эди;
- тадқиқотлар дала шароитида олиб борилмаган;
- цемент миқдорини 10% гача ошириб ўрганилганда мақсадга мувофиқ бўлар эди.

Ушбу диссертация иши магистрлик диссертациясига қўйилган талабларга мос келади. Магистрант Юсупалиев Умид Ғаниевич 5А341401-Автомобиль йўлларини лойиҳалаш ва қуриш мутахасисслиги бўйича магистрлик даражасини олишга муносиб деб хисоблайман ва ҳимояга тавсия этаман.

ЎзРАЙҚ. Умумий фойдаланишдаги автомобиль йўлларини қуриш ва реконструкция қилиш дирекцияси ДУК директор ўринбосари, т.ф.н. **Ф.Х. Бекназаров**

ТАЙЛҚЭИ 524-17 АЙЛ ва Қ гурух магистранти Юсупалиев Умид Ғаниевичнинг илмий ишлари

РЎЙХАТИ

№	Ишнинг номи	Қўл ёзма ёки чоп этилган	Нашриёт, журнал сони, йили ёки муаллифлик гувоҳномаси	Бетлар сони	Хаммуаллифлар
1	**2**	**3**	**4**	**5**	**6**
1.	Хизмат муддати тугаган цементбетон қопламаларини майдалаб йўл асоси учун цемент билан мустаҳкамлаб ишлатиш	Чоп этилган	“Автомобиль йўллари ва транспорти комплексида инновацион ғояларни амалга оширишда ёш мутахассисларнинг ўрни”. ТАЙЛҚЭИ, Тошкент, 2018.	4	(PhD) Амиров Т.Ж
2.	Йўл асоси учун ишлатиладиган цемент билан мустаҳкамланган чақиқтош-қум қоришмаларининг сифатини назорат қилишдаги муаммолар	Чоп этилган	“Автомобиль йўллари ва транспорти комплексида инновацион ғояларни амалга оширишда ёш мутахассисларнинг ўрни”. ТАЙЛҚЭИ, Тошкент, 2018.	3	(PhD) Амиров Т.Ж
3.	Тошкент вилояти автомобиль йўлларини геоахборот тизими орқали инвентаризация қилиш	Чоп этилган	ТАЙИ Хабарномаси, 2, Тошкен, 2018.	6	(DSc) СодиқовЖ.И

4.	Цемент билан мустаҳкамланган чақиқтош-шағал-қум қоришмасининг сиқилишдаги мустаҳкамлиги орқали эгилишдаги чўзилишга мустаҳкамлигини прогнозлаш	Қўл ёзма	ТТЙМИ Хабарномаси,2, Тошкент, 2019.	7	т.ф.д., профессор Адилходжаев А.И (PhD) Амиров Т.Ж
5.	Цемент билан мустаҳкамланган чақиқтош-шағал-қум қоришмаларининг таркибини танлашнинг компютер дастури		Ўзбекистон Республикаси Адлия вазирлиги ҳузуридаги интеллектуал мулк агентлиги		Адилходжаев А.И Амиров Т.Ж

Магистратура бўлими бошлиғи: М.А. Махамаджанов

Магистрант: У.Ғ. Юсупалиев

ELEKTRON HISOBLASH MASHINALARI UCHUN YARATILGAN DASTURNING RASMIY RO'YXATDAN O'TKAZILGANLIGI TO'G'RISIDAGI

GUVOHNOMA

СВИДЕТЕЛЬСТВО ОБ ОФИЦИАЛЬНОЙ РЕГИСТРАЦИИ ПРОГРАММЫ ДЛЯ ЭЛЕКТРОННЫХ –ВЫЧИСЛИТЕЛЬНЫХ МАШИН

O'ZBEKISTON RESPUBLIKASI ADLIYA VAZIRLIGI HUZURIDAGI INTELLEKTUAL MULK AGENTLIGI
АГЕНТСТВО ПО ИНТЕЛЛЕКТУАЛЬНОЙ СОБСТВЕННОСТИ ПРИ МИНИСТЕРСТВЕ ЮСТИЦИИ РЕСПУБЛИКИ УЗБЕКИСТАН

№ DGU 06567

Ushbu guvohnoma O'zbekiston Respublikasining «Elektron hisoblash mashinalari uchun yaratilgan dasturlar va ma'lumotlar bazalarining huquqiy himoyasi to'g'risida»gi Qonuniga asosan quyidagi EHM uchun dasturga berildi:

Настоящее свидетельство выдано на основании Закона Республики Узбекистан «О правовой охране программ для электронно-вычислительных машин и баз данных» на следующую программу для ЭВМ:

Sement bilan mustahkamlangan chaqiqtosh-shag'al-qum qorishmalarining tarkibini tanlashning kompyuter dasturi
Компьютерная программа подбора состава щебеночно-гравийно-песчаной смеси, укрепленной цементом

Talabnoma kelib tushgan sana:
Дата поступления заявки: **30.05.2019**

Talabnoma raqami:
Номер заявки: **DGU 2019 0741**

Huquq egasi(egalari):
Правообладатель(и):
Toshkent avtomobil yo'llarini loyihalash, qurish va ekspluatatsiyasi instituti qoshidagi "AVTOYO'LSIFAT" ilmiy-tadqiqot va ishlab chiqarish unitar korxonasi, UZ
Научно-исследовательское и производственное унитарное предприятие "AVTOYO'LSIFAT" при Ташкентском институте проектирования, строительства и эксплуатации автомобильных дорог, UZ

Dastur muallif(lar)i:
Автор(ы): программы
Adilxodjayev Anvar Ishanovich, Amirov Tursoat Jummayevich, Yusupaliyev Umid G'aniyevich, UZ

O'zbekiston Respublikasi elektron hisoblash mashinalari uchun dasturlar davlat reestrida 04.06.2019 yilda Toshkent shahrida ro'yxatdan o'tkazilgan.

Зарегистрирован в государственном реестре программ для электронно-вычислительных машин Республики Узбекистан, в г. Ташкенте, 04.06.2019 г.

Direktor v.v.b.
Вр.и.о. директора **Б. Сагдуллаев**

INTELLEKTUAL MULK AGENTLIGI

ЎЗБЕКИСТОН РЕСПУБЛИКАСИ
ОЛИЙ ВА ЎРТА МАХСУС ТАЪЛИМ ВАЗИРЛИГИ

ТОШКЕНТ АВТОМОБИЛЬ ЙЎЛЛАРИНИ ЛОЙИҲАЛАШ, ҚУРИШ ВА ЭКСПЛУАТАЦИЯСИ ИНСТИТУТИ

АВТОМОБИЛЬ ЙЎЛЛАРИ ВА ТРАНСПОРТИ КОМПЛЕКСИДА ИННОВАЦИОН ҒОЯЛАРНИ АМАЛГА ОШИРИШДА ЁШ МУТАХАССИСЛАРНИНГ ЎРНИ

...ФАОЛ ТАДБИРКОРЛИК, ИННОВАЦИОН ҒОЯЛАР
...ТЕХНОЛОГИЯЛАРНИ ҚЎЛЛАБ-ҚУВВАТЛАШ ЙИЛИ"ГА
...ГАН ИҚТИДОРЛИ ЁШЛАРНИНГ ИЛМИЙ-ТЕХНИК

АНЖУМАНИ

18-19 май 2018й.

Тошк... 2018

многообразии источников загрязнения атмосферного воздуха главным источником загрязнений является автотранспорт. На него приходится около 70% загрязняющих веществ. В связи с этим развивающиеся страны уделяют особое внимание озеленению автомобильных дорог. Насаждения вдоль автомобильных дорог используются не только как защитные, но и улучшают экологию и эстетический вид прилегающих к ним территорий.

Озеленение автомобильных дорог проводится с учетом агроклиматических условий районирования. К примеру, в России, Казахстане Белоруссии на заносимых снегом участках вдоль автомобильных дорог в районах с выраженной метелевой деятельностью ветров прибегают к снегозадерживающим лесным насаждениям.

В Беларуси для защиты автомобильных дорог от снежных заносов рекомендуется производить 1-2х-рядные посадки хвойных пород (ель, можжевельник, туя), 2-8-рядные — лиственных древесных пород и кустарников, а на бедных песчаных и избыточно увлажненных почвах — 4—6-рядные посадки шелюги красной и ивы белой. Причем полосы необходимо создавать на расстоянии 25—60 м от бровки земляного полотна при объемах снегоприноса 25—150 м^3 на 1 м дорог. [1]

Зарубежные специалисты предлагают сооружать экодуки. Экодук- это сооружение предназначенное исключительно для миграции животных, для того что бы они безопасно переходили транспортные магистрали. Экодуки преимущественно создаются из песчаного грунта и засаживаются растительностью.

Согласно исследованию 2005 года, почти 1.5 миллиона дорожных происшествий происходит каждый год только в США - из-за выбегающих на дорогу животных. Кроме того, некоторые разновидности исчезают из-за того, что дороги отделили их от их естественной среды обитания.

Впервые экодук был построен во Франции в 1950 году 20 века. В настоящее время лидером по количеству экодуков являются Нидерланды. В Нидерландах есть более 600 туннелей, устроенных под главными и второстепенными дорогами и магистралями, включая самый протяженный в мире экодук длиной в 800 метров. [2]

Рис.3. Экодук на шоссе А50, Нидерланды

Рис. 4. Экодук в национальном парке Банф в Альберте, Канада

Перекрестки для дикой природы стали все более популярными и в Канаде, и в Соединенных Штатах. Самые известные из них расположены в Национальном парке Банф в Альберте (рис.4), где природный парк разделен на две части большой коммерческой дорогой — Трансканадским шоссе. В США в общей сложности было построено несколько тысяч подобных перекрестков [2].

Стоит отметить, что экодуки - очень привлекательные с эстетической точки зрения сооружения. Они несомненно украшают пейзаж и привлекают внимание туристов, проезжающих по трассе.

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Хизмат муддати тугаган цементбетон қопламаларини майдалаб йўл асоси учун цемент билан мустаҳкамлаб ишлатиш

Юсупалиев У.Г. (магистрант- ТАЙЛҚЭИ)

Илмий раҳбар: Амиров Т.Ж.

Ўзбекистонда йўл-транспорт коммуникациялари ишлаб чиқаришнинг ҳамда ижтимоий инфратузилманинг муҳим таркибий қисми бўлиб, мамлакат ижтимоий-иқтисодий ҳаётида муҳим ўрин тутади. Хукумат дастурлари доирасида автомобиль йўлларини таъмирлаш, қуриш ва реконструкция қилиш лойиҳалари изчиллик билан давом эттирилмоқда.

Ушбу лойиҳаларнинг аксариятида юқори қатлам асос учун цемент билан мустахкамланган чақиқтош-қум-шағал аралашмасини қўллаш кўзда тутилган.

Йиллар ўтиши давомида хизмат вазифасини ўтаб бўлган цементбетон қопламалар ёки асфальтбетон қопламаларни майдалаб қурилиш материали сифатида қайта ишлатишни йўлга қўйиш муҳандис-йўлчилар олдидаги вазифалардан бири ҳисобланади. Асфальтбетон қопламаларини майдалаб уни маълум бир фоизлар даражасида асос қатламлари учун ишлатиш лойиҳа-смета ҳужжатларида берилади. Лекин, цементбетон қопламасини майдалашдан ҳосил бўлган материални ишлатиш учун норматив ҳужжатларда деярли маълумот ва кўрсатмалар мавжуд эмас. Бу каби материалларни ишлатиш энг аввало, атроф-муҳитни қурилиш чиқиндиларидан камроқ зарар етишига ва иқтисодий жиҳатдан қурилиш-монтаж ишларининг тан нархининг камайишига олиб келади.

Хизмат вазифасини ўтаб бўлган цементбетон қопламалар ёки асфальтбетон қопламаларни майдаланган материалларини цемент билан мустаҳкамлаб йўл асоси учун ишлатиш мақсадга мувофиқ бўлади. Чунки, бу материалларни қоплама учун физик-механик хусусиятлари талабга жавоб бермаслиги (ёки ўзгариб туриши) ва таркибидаги чанг миқдорининг кўплиги сабабли ишлатиш ноўрин.

[2] да "*Ноорганик ва органик боғловчи материаллар билан мустаҳкамланган йирик тошли, қумли, гилли грунтлардан ва* ***саноат чиқиндиларидан йўл*** *тўшамасининг асоси ва қопламаларини қуриш*" учун техник шартлар кўрсатилган. Шу норматив хужжатнинг 6.1 бандидага асосан: "*Грунтларни ва саноат чиқиндиларини боғловчилар билан аралаштириш ишлари қуйидагича бажарилади:*

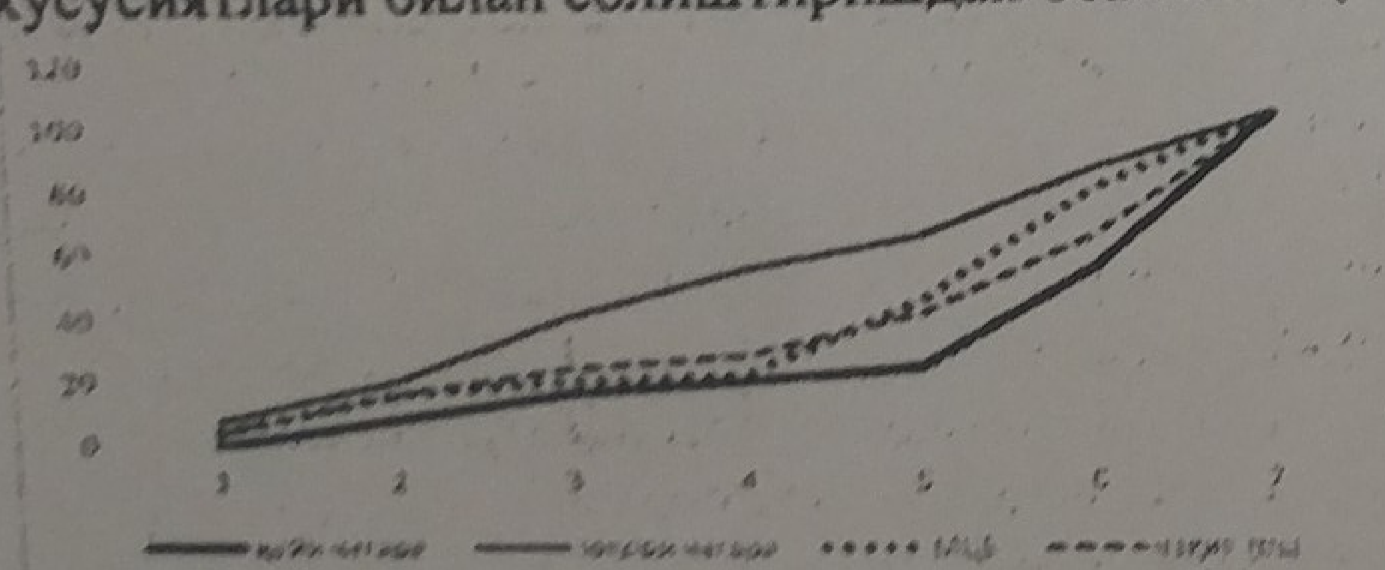
- *йўлда, махсус майдонларда ва карьерларда йўл фрезаси ва грунт аралаштиргич машиналар ёрдамида;*
- *аралаштиргич ускуналарда мажбурий тарзда аралаштириш билан. Катта бўлакли грунтлар ва саноат чиқиндиларни ёки уларнинг қоришмасини (камида 20-30% ҳажмда) майда қумлар ва боғловчи материаллар билан аралаштиришни эркин ҳаракатлантирувчи ускуналарда аралаштирилади.*" ***ва*** 6.12 ***бандида*** "*Саноат чиқиндаларни (кул-куюнди қоришмалари, тоғ жинсларининг майда қолдиқлари ва ҳакозо) ноорганик боғловчи материаллар билан мустаҳкамланса 6.6- 6.11- банд талабларига риоя қилиш лозим.*"

[2] да қопламаларни майдалашдан (саноат чиқиндалар) ҳосил бўлган материалларни ишлатиш учун талаблар кўрсатиб ўтилмаган.

Бугунги кунда ноорганик боғловчи материаллар билан ишлов берилаган чақиқтош-шағал-қум аралашмалари учун [1] мавжуд хужжат ҳисобланади. [1] га асосан бу норматив ҳужжат қопламаларни майдалашдан ҳосил бўлган материаллар учун тадбиқ этилмайди. (саноат чиқиндалар) ҳосил бўлган материаллар учун тадбиқ этилмайди.

Республикамизда бу масалага оид илмий изланишлар деярли олиб борилмаганлиги сабабли биз чет мамлакатлари олимларининг илмий адабиётларига эътиборимизни қаратдик.

[4] юқоридаги масалани кенг кўламда ўрганиб чиққан. Бундан ташқари [3] нинг такидлашича кўплаб лаборатория синовлари ва илмий тадқиқотлар натижасида майдаланган (қайта ишланган) материаллар табиий чақилган тош,қум ва шағалнинг ўрнини тўла ёки қисман боса олади. [4] энг авволо цементбетонни майдалашдан ҳосил бўлган материални табиий чақиқтошнинг хусусиятлари билан солиштиришдан бошлаган (1-расм).



1-расм. Табиий чақиқ тош билан майдаланган цементбетонни донадорлигини таққослаш

У чет мамлакатларда энг кўп ишлатиладиган цемент билан мустаҳкамланган охактошни ва майдаланган цементбетонни изланиш объекти қилиб танлаган. Шундан сўнг у қуйидаги тартибдаги қоришмалар асосида лаборатория синовларини олиб борди:

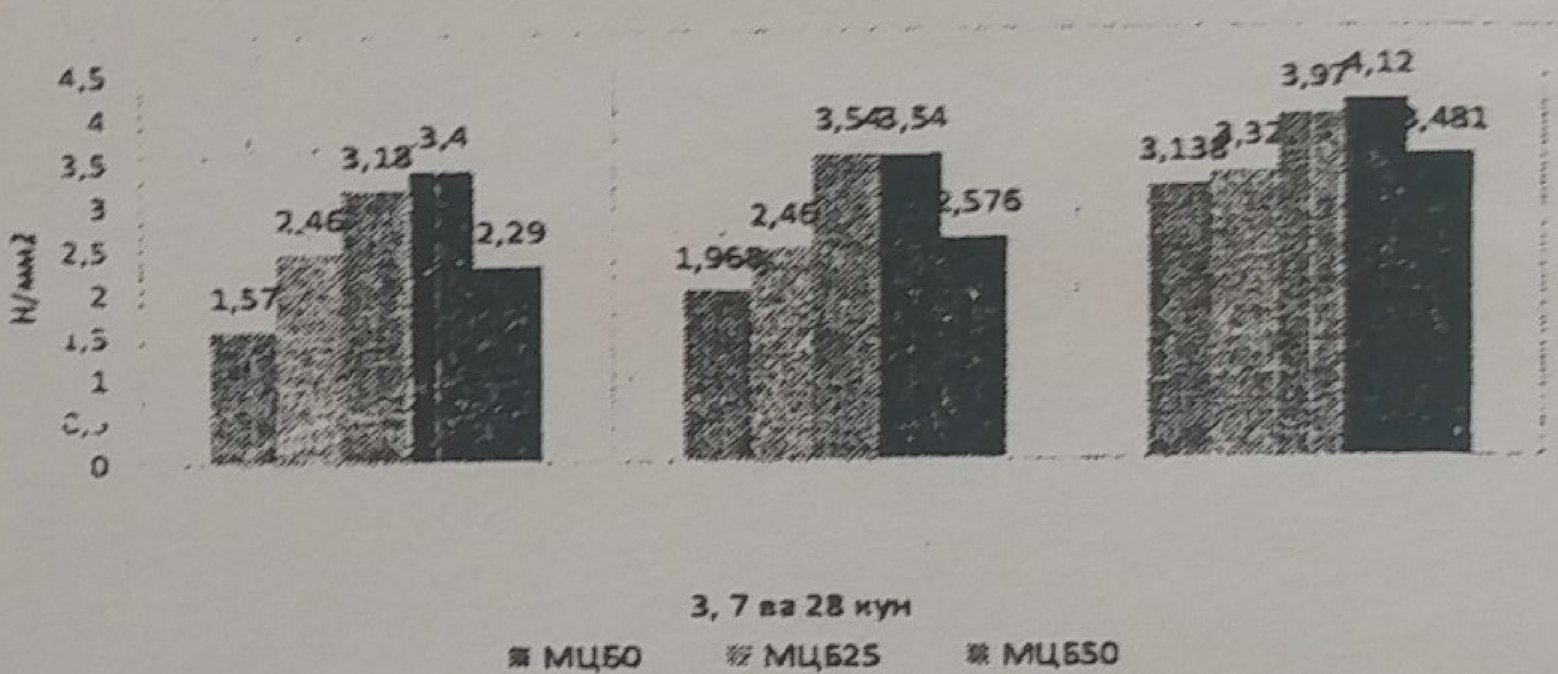
1) Майдаланган цементбетон ва оҳактош : (МЦБ: 0.0%, 25%, 50%, 75%, 100%).

2) Портланд цемент миқдори: 4%, 5%, 6% ва 7%.

Аралашмаларнинг оптимал намлиги ва максимал зичлиги 1-жадвалда берилган.

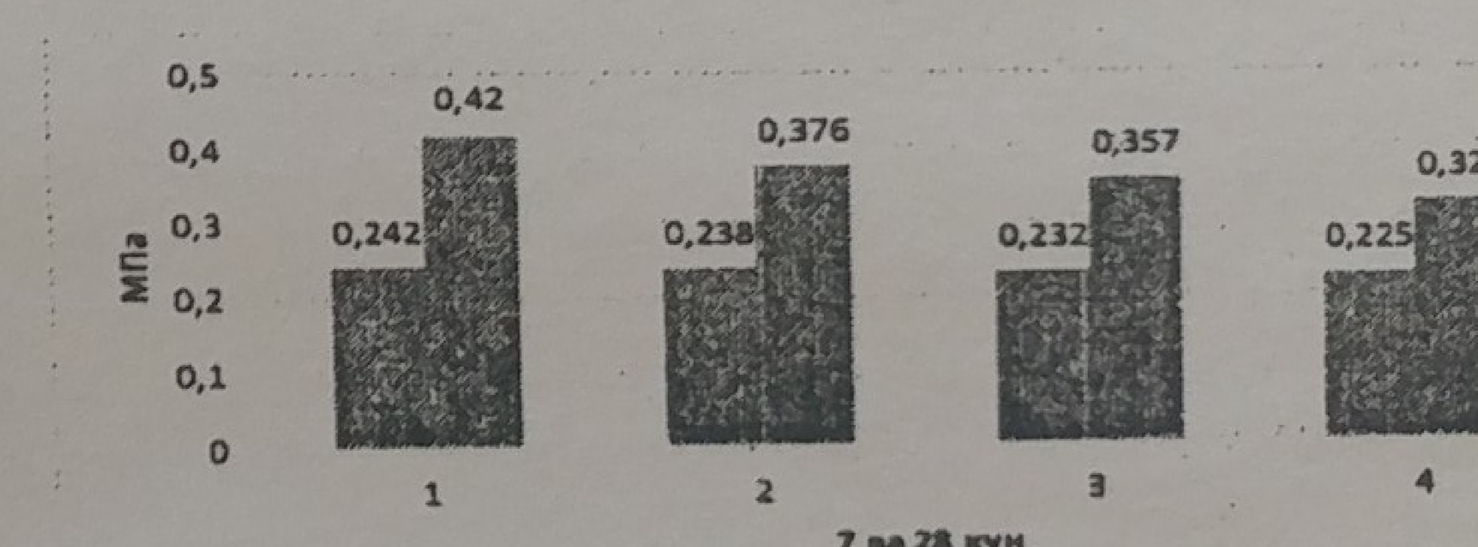
Аралашма номи	Материал (%)	Оптимал намлиги (%)	Максимал зичлиги (т/м3)
МЦБ0	100% ОТ	11.0	1.98
МЦБ25	75% ОТ+25% МЦБ	9.5	1.900
МЦБ50	50% ОТ+50% МЦБ	10.6	1.820
МЦБ75	25% ОТ+75% МЦБ	12.3	1.780
МЦБ100	100% МЦБ	14.7	1.740

1-жадвал. *ОТ-Оҳактош, МЦБ- Майдаланган цементбетон.*



2-расм. Цемент билан мустаҳкамлангандаги аралашмаларнинг сиқилишдаги мустаҳкамлик кўрсаткичлари.

Юқоридаги жадвал ва 2-расмдаги натижаларидан кўриниб турибдики майдаланган цементбетонни 50 дан 75 % оралиғида бошқа материалларга қўшиб ишлатиш юқорироқ мустаҳкамликка эга қоришма олишга имкон беради.



3.расм Цемент билан мустаҳкамлангандаги аралашмаларнинг эгилишдаги чўзилиш мустаҳкамлик кўрсаткичлари.

Хулоса қилиб шуни айтиш керакки майдаланган цементбетондан хосил бўлган материални йўл асоси учун цемент билан мустахкамлаб ишлатиш мумкин. Шу билан биргаликда бу материал учун норматив хужжат (техник шарт) ва лаборатория синовлари учун қўлланмалар ишлаб чиқилиши керак. Норматив хужжатларда майдаланган цементбетоннинг маркасига ва таркибидаги тўлдирувчиларига қараб қўйиладиган талаблар тавсифланиши керак.

Адабиётлар:

1. ГОСТ 23558 “Смеси щебеночно-гравийно-песчаные и грунты, обработанные неорганическими вяжущими материалами, для дорожного и аэродромного строительства. Технические условия”
2. ШНК 3.06.03-08 “АВТОМОБИЛЬНЫЕ ДОРОГИ”
3. Jimenez J, Ayuso J, Agrela F. Use of mixed recycled aggregates with a low embodied energy from non-selected CDW in unpaved rural roads. Build Mater 2012;34:34–43.
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Йўл асоси учун ишлатиладиган цемент билан мустаҳкамланган чақиқтош-қум қоришмаларининг сифатини назорат қилишдаги муаммолар

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Илмий раҳбар: Амиров Т.Ж

Ўзбекистон Республикаси Марказий Осиё минтақасининг чорраҳасида жойлашган бўлиб, минтақавий ҳамкорликни ривожлантириш учун қулай шарт-шароитлар яратади ҳамда транспорт коридорларини ривожлантириш учун минтақавий ва трансмиллий лойиҳаларда иштирок этиш учун қулай. Шуни таъкидлаш керакки, Ўзбекистон кенг кўламдаги йўллар тармоғи билан фахрланадиган мамлакатлардан биридир. Ўзбекистон миллий артериал йўлини ташкил этадиган автомобиль йўллари таъмирланиб реконструкция қилинди. Ўзбекистон миллий автомагистралини ташкил этувчи ва уни халқаро стандартларга яқинлаштирадиган автомагистраллар сифатини яхшилаш мақсадида халқаро кредит ташкилотларининг пул маблағларини жалб қилиш бўйича катта ишлар амалга оширилмоқда. Ўзбекистон Республикаси ҳукумати ва халқаро молия институтлари орасида бир қатор кредит битимлари имзоланди. Шуни таъкидлаш жоизки, ушбу шартномалар бўйича мамлакатта ажратилган кредитлар умумий суммаси 1,2 миллиард АҚШ долларидан ошади. Ушбу маблағлар 586 километрлик йўлларни қуриш ва реконструкция қилиш учун сарфланади. Шундан 379 километрлик йўл қисми цементбетон қопламали бўлади. Иқтисодий жиҳатдан цементбетон …манинг хизмат муддати асфалтбетонга нисбатан 12-15 йиллик муддатга …батан 25-30 йилгача чўзилади. Шу билан бирга, цементбетон қопламали …ларни таъмирлаш харажатлари асфалтбетон қопламали йўлларни …мирлашга нисбатан икки баробар арзонга тушади. Ўзбекистон …спубликаси Давлат инвестиция дастурлари доирасида ва Президент …орларига биноан 2008-2013-йиллар мобайнида Республика йўл …армаси томонидан 181 км автомобиль йўллари қурилиб, фойдаланишга …ширилди. Осиё тараққиёт банки (ОТБ) томонидан берилган 232,5 …он АҚШ доллари асосида хозирги вақтда Сурхондарё вилоятининг (… км), Наманган ва Тошкент вилоятларининг (58 км) автомобиль …ларини қайта қуриш ишлари олиб борилмоқда.

Юқорида кўрсатиб ўтилган автомобиль йўлларининг аксариятида …ори қатлам асос учун цемент билан мустахкамланган чақиқтош-қум-шағал …шмасини қўллаш лойиҳаларда кўзда тутилган.

Қурилиш ишларининг сифат назорати жараёнида ушбу материаллларни …нал таркибини танлашда, мустаҳкамлик кўрсаткичларини текширишда … зичланганлик даражаларини аниқлашда, бир қанча муаммолар келиб …моқда. Бугунги кунда ноорганик боғловчи материаллар билан ишлов …лаган чақиқтош-шағал-қум аралашмалари учун ГОСТ 23558-94 мавжуд …жат ҳисобланади.

[2] да мустаҳкамланган материалнинг сиқилишга, эгилишдан …зилишга, музлашга чидамлийликка ва донодорлик таркибига талаблар …рсатилган. Энг аввало, донадорлик таркибига эътибор қаратамиз (1-жадвал):

1-жадвал

Максимал зарра йирклиги, мм	Элакдаги тўла қолдиқ, мм									
	40	20	10	5	2,5	1,25	0,63	0,315	0,14	0,005
40	"0 10"	"20 40"	"35 65"	"50 80 "	"60 85"	"70 90 "	"75 95 "	"80 97"	"85 98"	"87 100"
20		"0 10"	"20 "40	"35 "65	"50 "80	"60 "85	"70 "90	"75 "95	"80 "97	"85 "100
10			"0 10 "	"25 "40	"45 "65	"60 "80	"70 "85	"75 "90	"80 "95	"85 "100
5				"0 10 "	"30 "40	"50 "65	"65 "80	"75 "85	"80 "90	"88 "100
2,5					"0 10 "	"30 "40	"55 "65	"70 "80	"80 "90	"88 "100
1,25						"0 "10	"35 "45	"60 "70	"75 "85	"85 "100

Демак, 40 мм ўлчамдаги материал 10% гача, 20 мм ўлчамдаги материал 40% гача ва 10 мм ўлчамдаги материал 45% гача ташкил килиши мумкин.

[2] га асосан мустахкамланган материал ва грунтларнинг таркиб танлашдаги максимал зичлиги ва намуналар тайёрлашда [3] дан урушлар сонини узгартириб фойдаланилади.

Лекин [3] га асосан ушбу ГОСТ таркибида 30% дан куп ўлчами 10 мм дан катта бўлган грунтлар (материаллар) учун талбиқ қилинмайди ва [3] нинг 6.1.4 га асосан грунт эланганда 10 мм ўлчамдаги элакдан 70% дан кам бўлмаган қисми ўтиши керак.

[2] да ўлчами 20 мм дан катта бўлмаган грунтлар (материалллар) учун гидравлик пресс ёрдамида 100х100х400 мм даги кубик колипдан фойдаланиш кўрсатилган. Лекин 40 мм гача бўлган материаллар учун хеч қандай кўрсатма йўқ. Қурилиш майдонининг ўзида намуналар тайёрлаш учун юқоридаги гидравлик пресс усули табийки муаммоли холат. Қурилиш майдонида намуналар тайёрлаш учун албатта механик қурилмалардан фойдаланиш қулай ва самарали ҳисобланади.

[3] да йирик таркибдаги мустаҳкамланган грунтларни (материаллар) мустаҳкамлик кўрсаткичларини текшириш, таркиб танлаш жуда кўплаб бахсли холатларни келтириб чикармоқда. Шу билан биргаликда [3] да кўрсатилган қурилма "(СОЮЗДОРНИИ туридаги қурилмалар)" ҳажм жихатидан (127,4х100 мм) материлларнинг донадорлигига нисбатан кичиклик қилади ва лаборатория ишларини олиб боришда ноқулайликлар келиб чиқади.

Хулоса қилиб шуни айтиш керакки, [2] учун қўшимча ва ўзгартиришлар киритилиши мақсадга мувофиқ. Бу билан максимал зичланганликни аниқлашда қўлланиладиган йирикроқ ҳажмдаги қурилма, хамда намуналар тайёрлаш ва синовдан ўтказиш учун йўрикномалар ишлаб чиқилади. Шу билан биргаликда норматив ҳужжатларни иқлим ва қурилиш ресурсларидан келиб чиқиб дунёнинг ривожланган давлатлари нормативларига (ASTM, AASHTO, BS ва DIN) яқинлаштириш мақсадга мувофиқ бўлади деган фикирдамиз.

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7. ГОСТ 22733 "Грунты. Метод лабораторного определения максимальной плотности"
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Асфальтбетон коплямали автомобиль йўлларида гилдирак изи деформациясининг юзага келиши

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Дунё бўйича 40 тадан давлат катори Ўзбекистон хам бевосита очик денгизга чиқиш имконияти йўқ. Бу Эса иктисодиёт ривожланиши насайтиришига, бу билан барқарор ривожланишига маълум салбий таъсир қилади. Шунинг учун хам автомобиль йўллари тизимларида ўзгаришлар бўлмокда.

Ўзбекистон Президенти Шавкат Мирзиёевнинг «Йўл хўжалигини бошкариш тизимини янада такомиллаштириш чора-тадбирлари тўғрисида»ги фармони асосида Ўзбекистон Автомобиль йўллари давлат қўмитаси ташкил этилди. Ҳозирги вақтда Республикамиз автомобиль йўллар тармоғи 183000 кмдан ортиқ.

Бу ўзгаришлар автомобил йўллари соҳасидаги долзарб муаммоларни тадкиқ етишни жадаллаштиришни талаб этади. Автомобиль йўлларидаги долзарб муаммолардан бири асфальтбетон қопламали автомобиль йўлларида гилдирак изи деформациясини юзага келишидир.[1]

Автомобил йўлларида ғилдирак изи деформациясининг хосил бўлишига иккита асосий фактор таъсир қилади.

- Об-ҳаво ва иклим шароитининг таъсири;
- Автомобиллардан бир ўққа тушадиган юкнинг таъсири;

Ғилдирак изининг пайдо бўлишига иқлим омилларининг таъсири.

Хаво хароратининг ғилдирак изининг пайдо бўлишига тўғридан тўғри таъсир кўрсатади. Ғилдирак изи деформациясининг чуқирлиги хаво харорати ва оғир юк автомобилларининг бир издан ўтишлар сонига боғлиқлиги қуйидаги математик модель [3].

$h_k = a * N^b \cdot T^Q$

Bu yerda: N- Оғир юк автомобилларнинг ўтишлари сони. авто/сутка

T – Асфальтбетон коплама харорати. С°

b – юкланишнинг кучайиш коэффиценти .

a va Q - Асфальтбетон қоплама шаклининг боғлиқлик коэффиценти .

Харакат жадаллиги хаво хароратига нисбатан ғилдирак изи пайдо бўлишига таъсирини, бу тадкикот объекти қилиб танлаб олинган М 41 «Бишкек-Душанбе-Термиз» асфальтбетон копламали автомобиль йўлнинг 1616-1621 км оралиғида ўлчаш натижалар асосида олиб борилган.

Юкорида бажарилган ўлчов ишларидан кўриниб турибдики, хаво харорати юкори бўлганида яъни харорат 50°Сдан юкори бўлганда (лойихалаётганда меёрий хужжатлар бўйича 50° С га лойихаланади) оғир юк автомобилларини куннинг хаво харорати юкори бўладиган кисмида

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Муассис – Тошкент автомобиль йўлларини лойиҳалаш, қуриш ва эксплуатацияси институти

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МУНДАРИЖА

Обустройства автомобильной дороги оказывает влияние на безопасность, удобства и комфортабельности движения, а также на благоустройства автомобильных дорог.

Благоустройства автомобильной дороги оказывает влияние на безопасность, удобства и комфортабельности движения, а также на обустройства дороги. Архитектурно-ландшафтное проектирование оказывает влияние на безопасность, удобства и комфортабельности движения, а также на обустройства и благоустройства автомобильных дорог. Окружающая среда в свою очередь оказывает влияние на обустройство и благоустройство и архитектурно-ландшафтное проектирование и безопасность, удобства и комфортабельность движения.

Выводы:

1. В целях обеспечения удобства и безопасности движения необходим системный подход на обустройство и благоустройство и архитектурно-ландшафтное проектирование.

2. Для обеспечения устойчивости деревьев и кустарников климатическим условиям необходимо разработать классификацию деревьев и кустарников с учетом требований агроклиматического районирования территории Республики Узбекистан.

3. Разработать принципы обустройства автомобильных дорог с учетом требований безопасности и комфортабельности движения и окружающей среды.

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УДК 625.7/.8

ТОШКЕНТ ВИЛОЯТИ АВТОМОБИЛЬ ЙЎЛЛАРИНИ ГЕОАХБОРОТ ТИЗИМИ ОРҚАЛИ ИНВЕНТАРИЗАЦИЯ ҚИЛИШ

Ж.И.СОДИҚОВ, У.Г. ЮСУПАЛИЕВ

Тошкент автомобиль йўлларини лойиҳалаш, қуриш ва эксплуатацияси институти

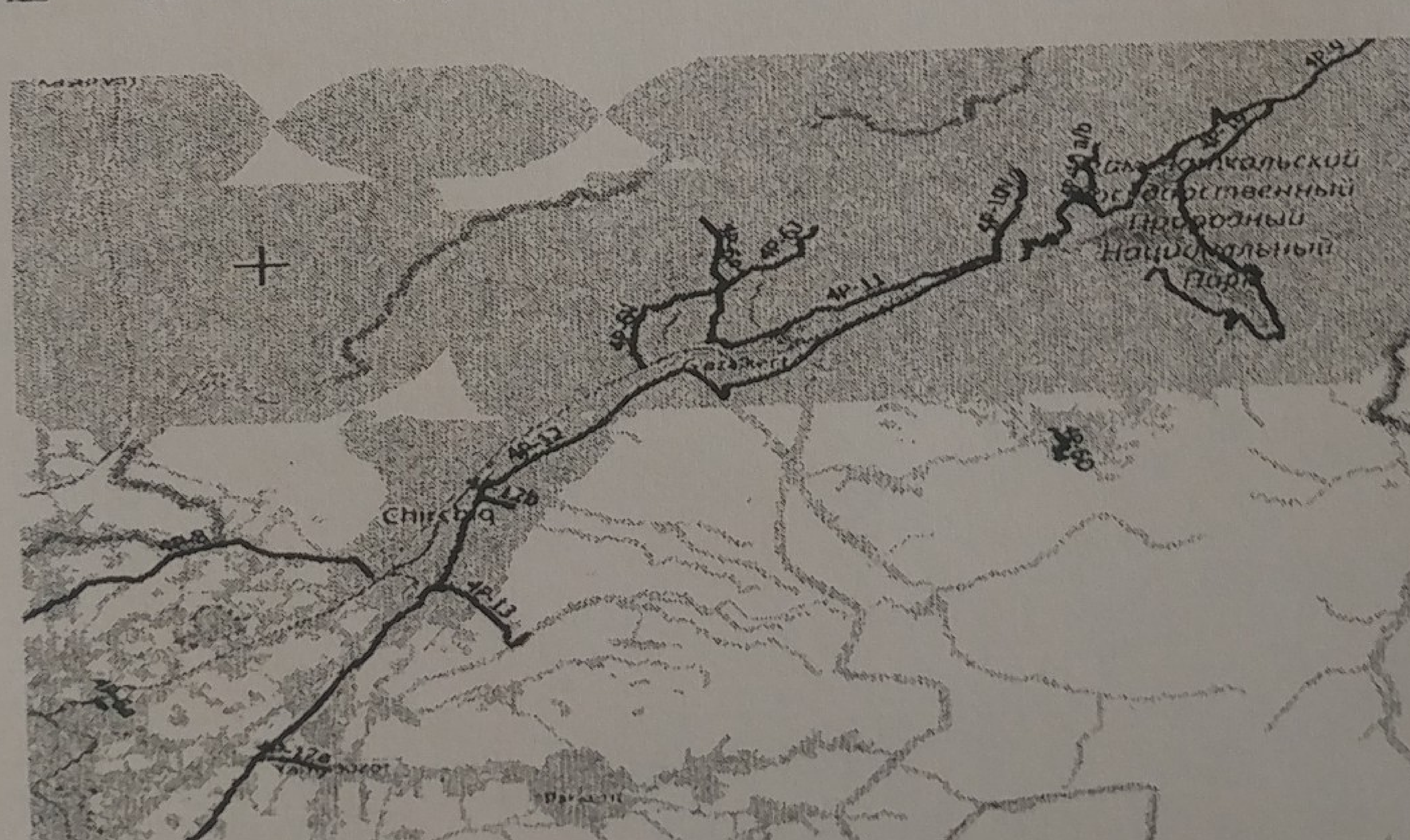
Мақолада Тошкент вилояти ҳудудида жойлашган автомобиль йўлларни QGIS дастури ёрдамида харитага паспорт маълумотлари билан жойлаштириш ва уларни таҳлил қилиш масаласи кўриб чиқилган. Ўз навбатида бу услуб автомобиль йўлларининг ва сунъий иншоотларнинг маълумотларини қисқа муддатда қидириб топиш, тахрирлаш ва маълумот олишга ёрдам беради.

В статье рассматривается вопрос, о том какие преимущества дает использование геоинформационных систем (QGIS) при составлении карт автомобильных дорог, *расположенных на территории Ташкентской области. Также, рассмотрены вопросы, связанные непосредственно с размещением дорог на электронные карты, анализ и занесение необходимых паспортных дынных в электронную базу данных*

The article discusses the advantages of using geographic information systems (QGIS) in mapping the roads located in Tashkent region. It will also discuss the process of incorporation of the roads to the maps, analysis, and entry of necessary technical data in the database.

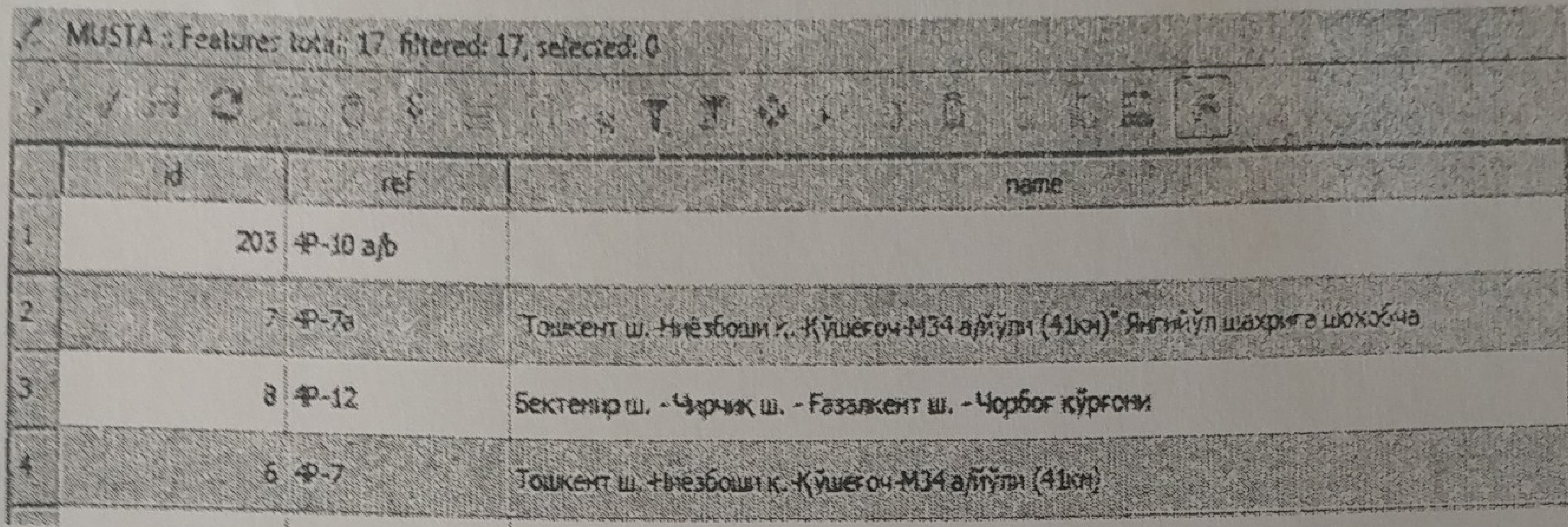
Йўл хўжалиги ҳар қандай мамлакат иқтисодиётининг энг муҳим тармоқларидан бири ҳисобланади. Автомобиль йўллари ҳар қандай мамлакатнинг "қон томири" деб юритилади. Бугунги кунда мамлакатимизда барча соҳаларни ривожлантиришга қаратилган чора тадбирлар, қарорлар ва лойиҳалар ишлаб чиқилмоқда. Шулардан бири сифатида Узбекистон Республикасида геоахборот тизимларини ривожлантириш ва маълумотлар базасини электрон шаклини яратишга қаратилган [3]. Шу мақсадда, Тошкент вилоятида жойлашган автомобиль йўлларини маълумотлар базаси билан биргаликда геоахборот тизимига жойлаштирилди. Энг аввало Тошкент вилоятида жойлашган йўлларнинг ҳалқаро ва давлат ахамияти кесимида тематик харитаси QGIS дастури, Open Street Map ва Bing Maps иловаларидан фойдаланган ҳолда яратилди. Тошкент вилояти худудидан ҳалқаро аҳамиятидаги М-34 "Тошкент – Душанбе" 60 км, М-39 "Алмати – Бишкек – Тошкент – Шахрисабз - Термиз" 65 км ва А-373 "Тошкент – Ўш" 136 км узунликда автомобиль йўллари ўтган. Ушбу йўлларнинг 168 км I-тоифа, 86 км II-тоифа ва 7 км III-тоифага тегишли. Шу билан биргаликда 71 км цементбетон, 182 км асфальтбетон ва 8 км қора чақиқтош қопламали автомобиль йўллари мавжуд [4]. Тошкент вилояти ҳудудида давлат аҳамиятидаги 80 та 1629 км узунликдаги автомобиль йўллари мавжуд. Буларнинг 90 км цементбетон, 1374 км асфальтбетон, 160 км қора чақиқтош, 3 км шағал қопламали ва 2 км грунтли йўллар ташкил этади. Бундан кўриниб турибди-ки, автомобиль йўлларини таснифини қайта кўриб чиқиш, тўғри таснифлаш масаласи долзарб муаммо эканлиги маълум бўлди.

Тошкент вилояти ҳудудида жойлашган давлат ахамиятидаги 17 та (4Р6а, 4Р6б, 4Р6в, 4Р6д, 4Р6ж, ,4Р7, 4Р7а, 4Р8, 4Р9, 4Р10, 4Р10в, 4Р11, 4Р12, 4Р12а, 4Р12б, 4Р12г,4Р13) автомобиль йўлларини танлаб олинди. Сўнгра ушбу йўлларни QGIS дастури ёрдамида харитага жойлаштирилди. Ушбу йўлларнинг маълумотларининг устуда амаллар бажариш мақсадида алоҳида қатлам сифатида сақланди (1-расм).



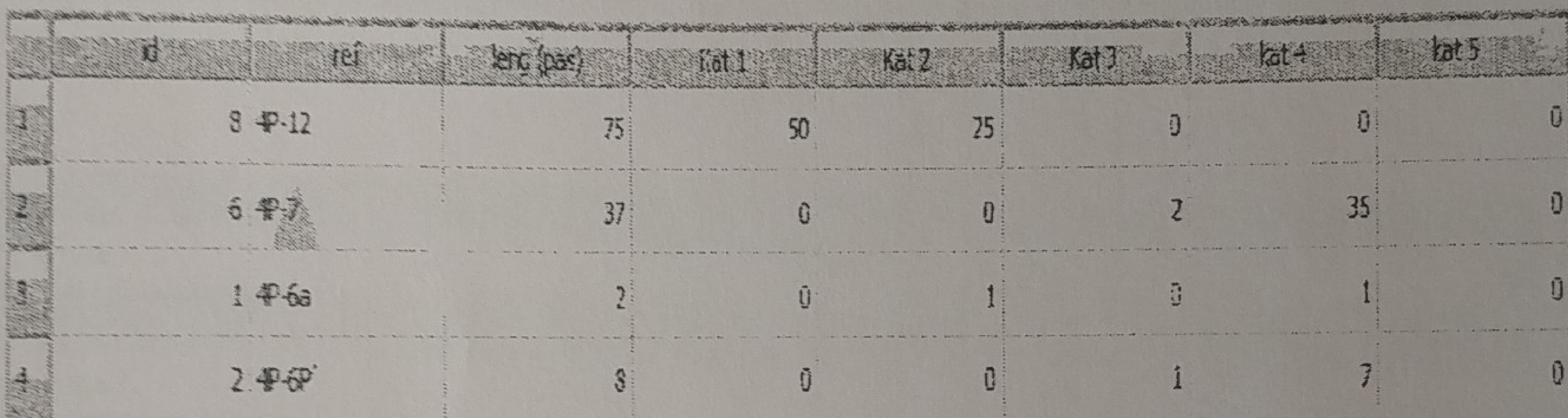
1-расм: Тошкент вилояти ҳудудида жойлашган давлат аҳамиятидаги автомобиль йўлларининг харитада жойлашуви

Кейинги босқичда МҚН 01-2007 асосида таёрланган йўлларнинг паспортларини электрон шакли яратилди. Йиғилган маълумотлар асосида ҳар бир йўлнинг ўзига тегишли бўлган маълумотлари атрибути яратилди. Ҳар бир йўл учун унинг номланиши, йўлнинг паспорт рақами, узунлиги, тоифаси, қоплама тури ва сунъий иншоотлар ҳақидаги малумотлар базаси яратилди. Сунъий иншоотлар ҳақидаги малумотларда кўприклар ва сув ўтказувчи қувурларнинг умумий узунлиги, конструкцияси тури ва ҳар бир турнинг узунлиги ҳақида малумотлар киритилган.


MUSTA :: Features total: 17, filtered: 17, selected: 0

	id	ref	name
1	203	4P-10 a/b	
2	7	4P-7a	Тошкент ш. -Ниёзбоши қ. -Қўшеғоч-М34 а/йўли (41км)" Янгийўл шаҳрига шохобча
3	8	4P-12	Бектемир ш. - Чирчиқ ш. - Ғазалкент ш. - Чорбоғ қўрғони
4	6	4P-7	Тошкент ш. -Ниёзбоши қ. -Қўшеғоч-М34 а/йўли (41км)

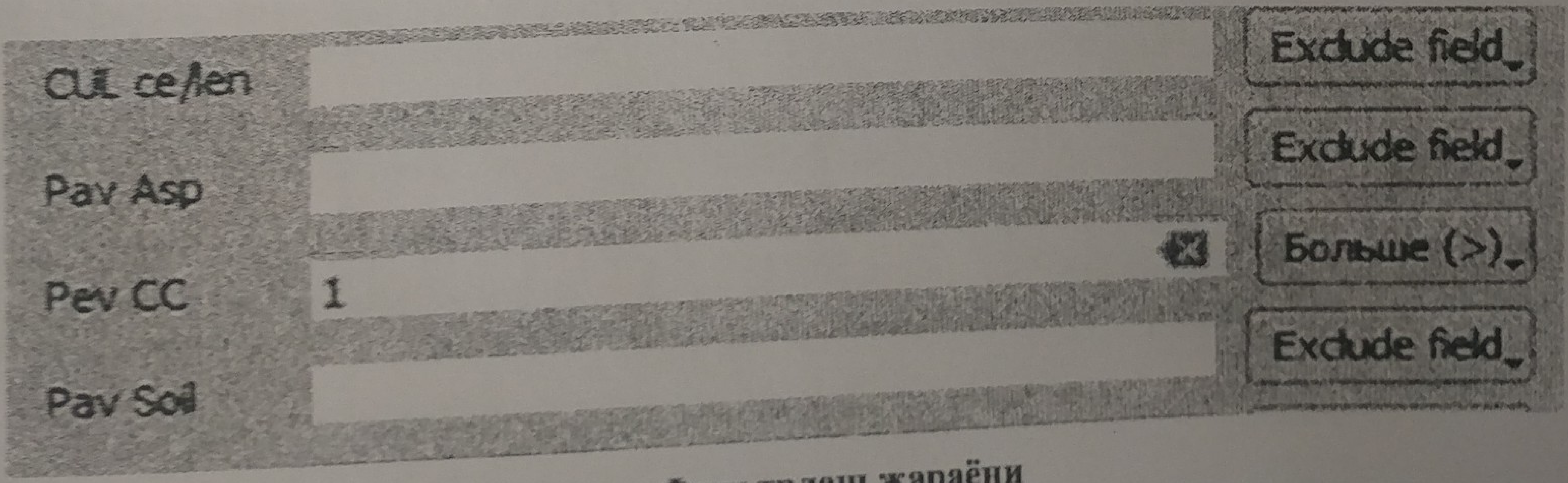
2-расм. Йўлни рақами ва номланиши



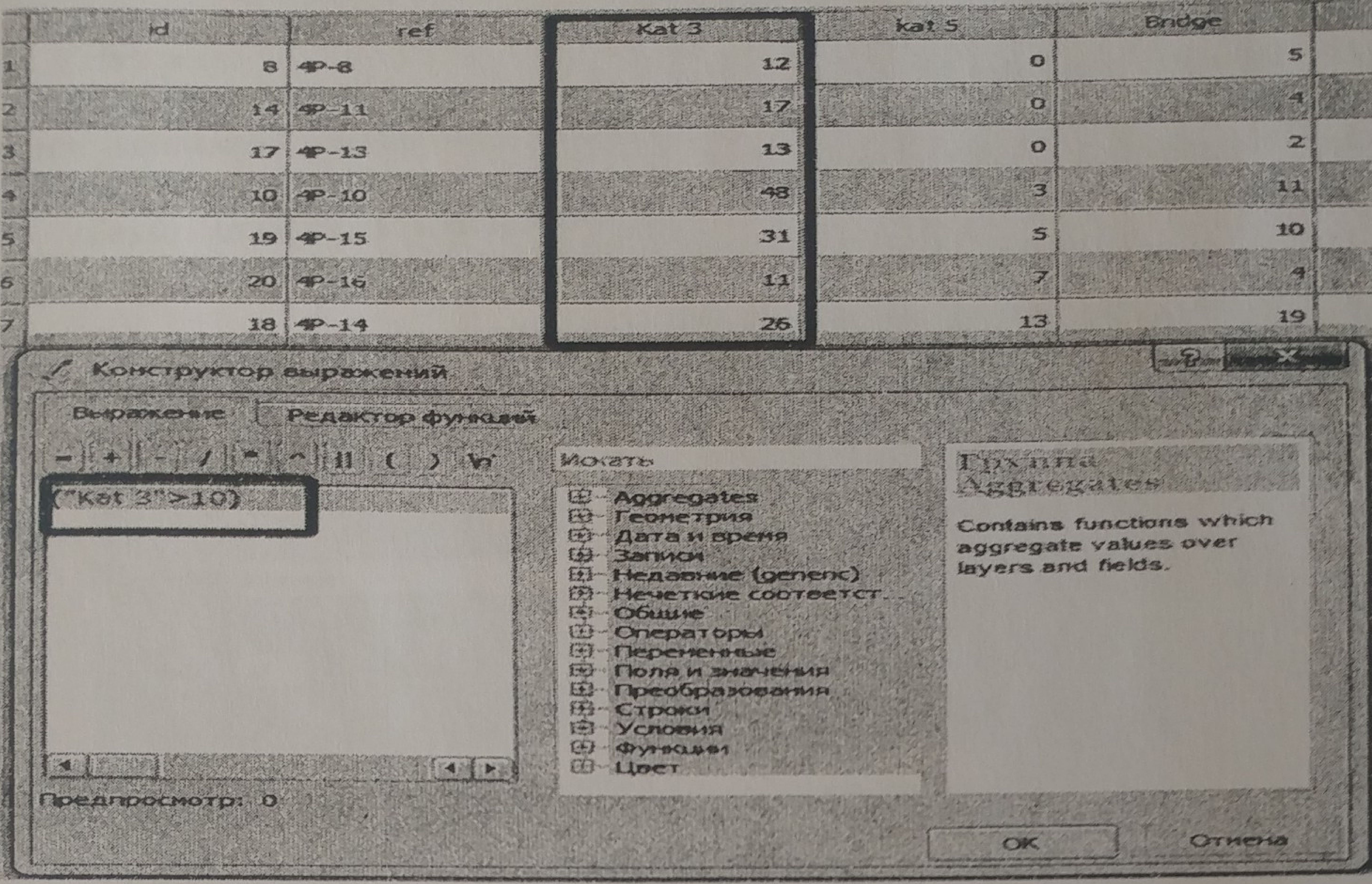
	id	ref	leng (pas)	Kat 1	Kat 2	Kat 3	Kat 4	Kat 5
1	8	4P-12	75	50	25	0	0	0
2	6	4P-7	37	0	0	2	35	0
3	1	4P-6a	2	0	1	0	1	0
4	2	4P-6P	8	0	0	1	7	0

3-расм. Йўлни атрибутлари

2 ва 3 расмларда автомобиль йўлларига тегишли бўлган малумотларнинг атрибут шаклида кўриниши акс этган. Юқоридаги малумотлар базаси асосида йўллар ҳақидаги кўплаб малумотларни қисқа муддат ва қийинчиликларсиз саралаш ва тахрирлаш мумкин. Бунга мисол қилиб юқорида танлаб олинган йўллардан III-тоифага тегишли қисми 10 км дан кўп бўлган йўлларни саралаб оламиз (5-расм). Танлаб олинган йўллардан цементбетон қопламали йўлларни саралаб олиш масаласини вазифа қилиб оламиз. Бунинг учун энг аввало атрибутлар жадвалидан Ctrl+F тугмаси орқали 4-расмдаги фильтр дарчаси очилади. Сўнгра бетон қопламалар қаторига *"больше >1"* ёзилади.

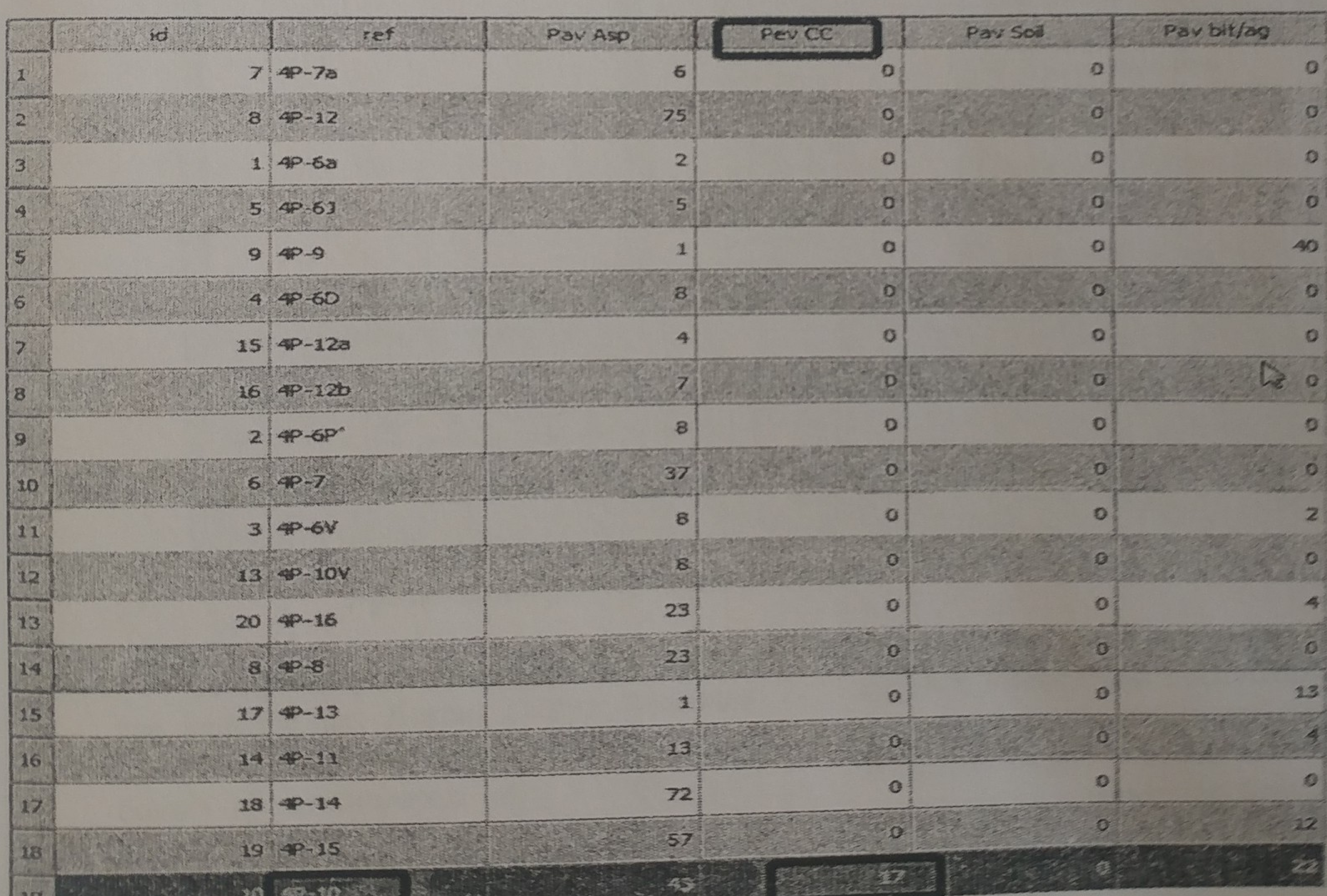


4-расм. Фильтрлаш жараёни



	id	ref	Kat 3	kat 5	Bridge
1	8	4P-8	12	0	5
2	14	4P-11	17	0	4
3	17	4P-13	13	0	2
4	10	4P-10	48	3	11
5	19	4P-15	31	5	10
6	20	4P-16	11	7	4
7	18	4P-14	26	13	19

5-расм. Саралаш модули ва саралаб олиш натижаси

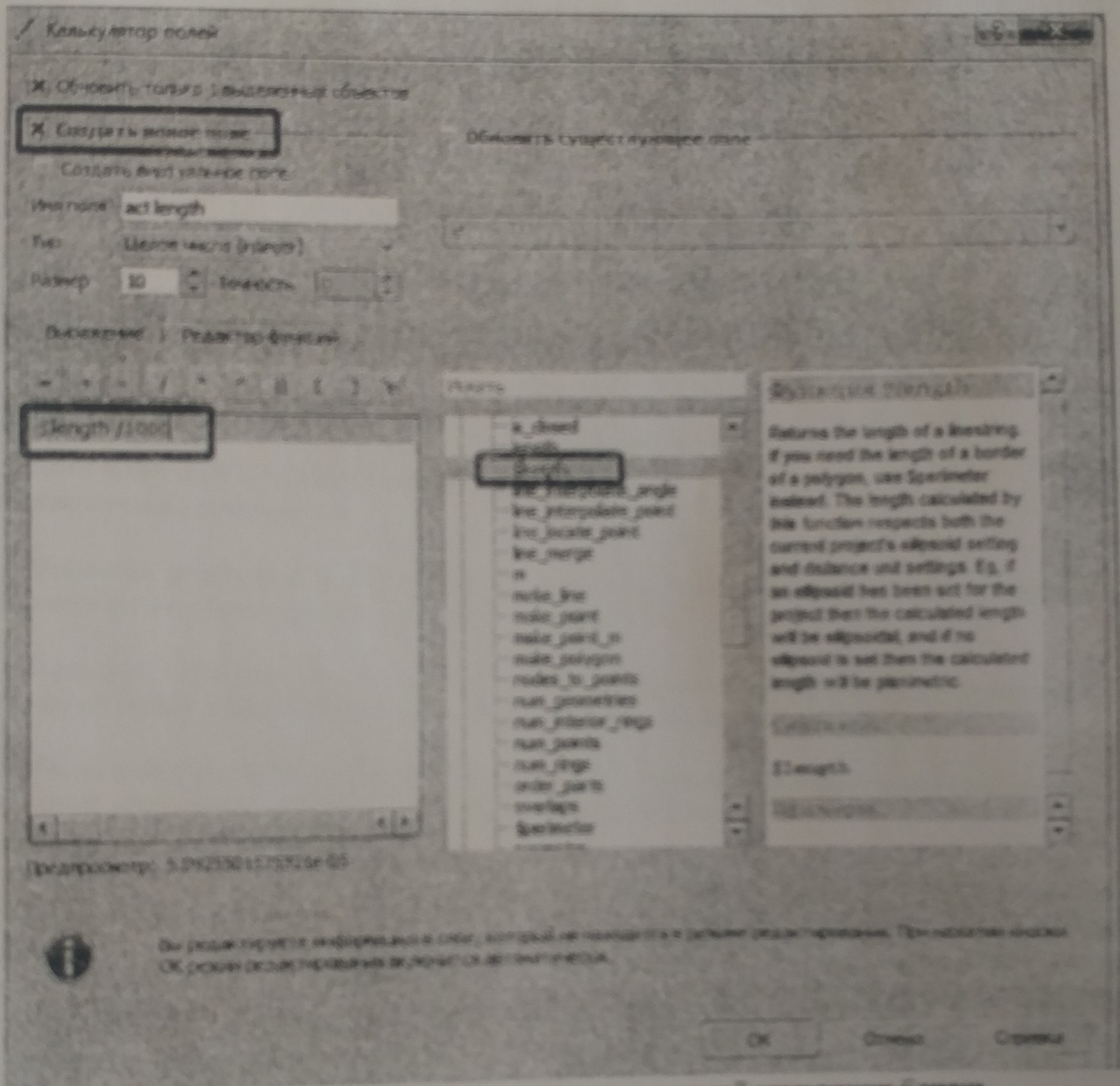


	id	ref	Pav Asp	Pev CC	Pav Soil	Pav bit/ag
1	7	4P-7a	6	0	0	0
2	8	4P-12	75	0	0	0
3	1	4P-6a	2	0	0	0
4	5	4P-6J	5	0	0	0
5	9	4P-9	1	0	0	40
6	4	4P-6D	8	0	0	0
7	15	4P-12a	4	0	0	0
8	16	4P-12b	7	0	0	0
9	2	4P-6P'	8	0	0	0
10	6	4P-7	37	0	0	0
11	3	4P-6V	8	0	0	2
12	13	4P-10V	8	0	0	0
13	20	4P-16	23	0	0	4
14	8	4P-8	23	0	0	0
15	17	4P-13	1	0	0	13
16	14	4P-11	13	0	0	4
17	18	4P-14	72	0	0	0
18	19	4P-15	57	0	0	12
19	10	4P-10	43	17	0	22

6-расм. Цементобетон копламали йўлларни аниклаш

Натижада 4Р-10 "Чорбоғ сув омбори халқа йўли" нинг 17 км қисми цемент бетон қопламали эканлигини аниқланди (6-расм).

Баъзи ҳолатларда автомобиль йўлларининг паспортда берилган узунлиги ҳақиқий узунлигидан фарқ қилиши мумкун. Йўлларнинг ҳақиқий узунлигини йўлларнинг сони ва ўлчамидан қатъий назар QGIS дастурининг "калькулятор полей" модули орқали ўлчаш имкони мавжуд (7-расм).



7-расм. Калькулятор модули орқали ҳақиқий узунликни ўлчаш

Юқорида фақатгина бир неча мисоллар келтирилди. Лекин, дастур ёрдамида сунъий иншоотлар, қоплама турлари ва бошқа кўрсаткичларини асос қилиб олган ҳолда саралаш ва қидириш имкони мавжуд.

Хулоса қилиб айтиш керакки, автомобиль йўллари ҳақидаги маълумотларни геоахборот тизимлари дастурларида маълумотлар базасини яратиш ҳозирги кундаги Ўзбекистон Республикаси йўлчиларининг олдида турган энг долзарб масалалардан бири ҳисобланади. Чунки, бу дастурлар ва малумотлар базаси ёрдамида биргина мутахассис қисқа муддат интервалида ўнлаб муҳандис ёки мутахассис бажариши керак бўлган ишни бажариш мумкин.

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ГИДРОЛОГИК ҲИСОБЛАШЛАРДАГИ ТОҒОЛДИ СУВ ҲАВЗАЛАРИНИНГ МОРФОЛОГИК КЎРСАТКИЧЛАРИ ВА УЛАРНИ АНИҚЛАШ УСУЛЛАРИ

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Мақолада гидрологик ҳисоблашлардаги тоғолди кичик сув ҳавзаларининг морфологик кўрсаткичлари ва уларни аниқлаш усуллари келтирилган.

В статье приводятся расчетные методы определения морфологических параметров предьгорных малых водных бассейнов необходимые при гидрологических расчетах.

The article presents the calculation methods for determining the morphological parameters of foothill small water basins necessary for hydrological calculations.

Сув ва сел тошқинларининг шаклланиши умумий қонуниятларни ёритишда, бир хил минтақавий худудларнинг *физгеографик шароитларини белгиловчи:* ҳавзанинг майдони (F), баландлиги (Z), ҳавза баландлигининг ўртача квадратик фарқи (σ), ўзаннинг қиялиги (J), ҳавзадаги асосий ўзаннинг узунликлари (L) асосий *параметрлар* ҳисобланиб, уларнинг қийматларини аниқлаш талаб этилади [1,2]. Ҳисобланган ушбу параметрлар, кейинги ўринларда *морфологик кўрсаткичлар* миқдорини баҳолаш, ҳисобий қийматларини аниқлаш, уларнинг боғланишлар қонуниятини таҳлил этиш, сув ва сел тошқинларни шаклланишидаги минтақавий худудларнинг гидрологик қонуниятларини очишга, ҳавзадаги оқимнинг миқдорий қийматларини белгилашда, улардан гидрологик ҳисоблашларда фойдаланиш, ҳамда уларнинг ўзаро боғланишларига асосланган усулларни қўллашга ва яратишга имкон беради [3,5,6]. Қуйида ана шу кўрсаткичларнинг қийматларини аниқлаш усулларни келтирамиз.

Ҳавзанинг майдони (F) .

Дарё водийларда лойиҳаланётган иншоотнинг юқори қисмидаги атмосфера ёғинларидан оқим ҳосил этувчи ер юзасининг қисмини *сув тўпловчи майдон (ҳавза)* деб юритилади. Ҳавзанинг майдонини, яъни сув тўпловчи майдоннинг чегаралашда *сув айригич чизиқдан* фойдаланилади. Майдоннинг юзаси йирик масштаб-