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MODELING AND GEOTECHNICAL ZONING OF GEOTECHNICAL PROPERTIES OF SOILS IN FERGANA REGION

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Abstract
This in the article Soils of the Fergana region modeling geotechnical properties and the area geotechnical risk to the level see zoning according to scientific and methodological approach has been developed. First of all, the field and laboratory tests results (φ , c, E, g , Cc, cv and others) based on geotechnical information base formed, each X, Y, Z coordinates for a point, soil type, layer code, experiment (X_test), characteristic (X_k) and computational (X_d) parameters one to the system was brought. Then geostatistician methods – variogram analysis and kriging interpolation – using of parameters spatial distribution modeled by , φ , c, E, Cc, cv isoline and superficial maps created. Geotechnical parameters layers in a GIS environment land under water level, salinity, relief slope, seismic zoning such as thematic layers with integration geotechnical and seismogeotechnics risk level complex was evaluated. As a result, By Fergana region relatively comfortable, careful approach required and geotechnical in terms of complicated zones separated and every for one zone research size, foundation types choice and additional constructive measures according to recommendations have been developed. Proposal done approach province on a scale territorial planning, new construction and infrastructure projects geotechnical in terms of in justification application possible was effective scientific and practical the platform shapes.

Keywords: Fergana region, soil geotechnical properties , geotechnical modeling , geotechnical zoning , geostatistics , variogram , kriging, GIS technologies , geotechnical information base , geotechnical risk , seismogeotechnical assessment.

Introduction

Fergana in the province construction and infrastructure objects in design basis of the soil correct geotechnical properties assessment with together, this characteristics by region distribution visual in appearance Expression is also important. importance profession Because in real conditions of the ground physical-mechanical and deformation in the parameters strong spatial variability observed: alluvial-proluvial beds, irrigated salty fields, loess and collapsing layers, earth under waters level and seismic in the circumstances differences as a result one how many kilometers in the distance geotechnical features sharp changing departure possible. In such circumstances separately wells or at points taken test to the results based on a single " average " conclusion for the entire region release in practice construction safety enough at the level provide cannot. Therefore, Fergana in the province geotechnical features **modeling** and

geotechnical zoning issue separately scientific and practical direction as consideration necessary.

Fergana in the province wide widespread grunts for field and laboratory tests methodology improved, computational-geotechnical parameters statistic approach based on determine them, regional geotechnical information to the base placement principles have been developed . Now these in the department this information base and accounting parameters based on **geotechnical modeling,** that is Like ph , c, E, g , Cc, cv, Dr of parameters spatial distribution , in their GIS environment interpolation , 2D and 3D geotechnical models and maps creation , as well as the territory of Fergana region geotechnical risk to the level see zoning issues is illuminated .

Modern geotechnics in science geotechnical modeling is only separately sections according to calculation not , maybe **spatial and probability approaches relied on without** of the area geotechnical status complex mapping and is a process of forecasting . In this, GIS (geographic information system) systems) and digital relief from models active use As a result, soil parameters time and in space changes visual , analytical and forecast doer in forms expression possible Geotechnical models various in appearance to be possible :

- layered geological-geotechnical model (vertical sections according to) ;
- parameters according to isolinear maps (e.g. , by φ , c , or E);
- 3D blocky geotechnical model (x, y, z dimensions) ;
- geotechnical danger maps (subsidence , slip , liquefaction and others according to) .

Global and regional at the level soil properties digital to modeling related many in works (e.g. SoilGrids , WISE, SSURGO and others) geostatistics interpolation , machine education algorithms , geostatistical kriging methods , regression models such as approaches used , physicochemical and hydraulic parameters spatial distribution identified . At the level of Fergana region of the ground geotechnical parameters the same in modeling conceptual from the approaches , but to **regional conditions customized** in appearance use possible .

Fergana of the province geological-geotechnical under the circumstances to modeling impact the main factors that one how many to the group separation possible :

1. **Geological factors** – alluvial , proluvial , deluvial beds , their granulometric composition , layers thickness and spread ;
2. **Hydrogeological factors** – land under waters level depth , their mineralization , seasonal changes ;
3. **Regional seismic factors** – seismic zoning maps , seismic amplifier of layers availability ;
4. **Anthropogenic factors** – irrigation networks , collector-drainage network , man -made loads , dense construction regions and etc.

Geotechnical in modeling this factors, soil parameters background in the background additional " thematic " layers ” in a GIS environment combine important because this geotechnical risk zones right in determining solution doer role plays .

geotechnical information base (ID, X, Y, Z, ground type , test types , X_test , X_k , X_d and etc.) with GIS integration will be done and every one parameter for separately **spatial information layer** harvest On this basis :

- known depth by ranges (e.g. 0–5 m, 5–10 m) φ , c, E, γ and other of parameters interpolated maps is drawn up ;
- geostatistician methods using of parameters reliability interval is evaluated ;

- of the ground geotechnical risk indicators (e.g. , precipitation) coefficient high zones , salinity strong areas , seismic amplifier layers) are separated and cartographic in appearance is expressed ;
- finally Fergana of the province construction for comfortable , careful requiring an approach and restrictions with design possible was geotechnical zones separate is displayed .

Geotechnical zoning through design and search size optimization possible For example , geotechnical features stable and danger in low- level zones field and laboratory tests size known at the level shorten , but complicated and dangerous In the regions , on the contrary , additional sounding and deepened tests number increase offer to be done This approach is possible . one from the side geotechnical security if it provides , the second from the side search and design expenses makes it acceptable .

Also, geotechnical models and zoning results Fergana in the province **strategic planning** and territorial development also important in developing programs information source to be service to do possible . Large road and transport infrastructure projects , industry zones , new residential areas , hydraulic engineering buildings location when choosing geotechnical zoning basic technical maps documents in line introduction to the goal Especially seismic active in the regions of the ground dynamic answer into account 3D geotechnical model obtained and zoning information seismogeotechnics based decisions acceptance to do opportunity gives .

Thus, this in the department Soils of the Fergana region modeling of geotechnical properties , geotechnical parameters in a GIS environment spatial analysis and the area geotechnical risk to the level see zoning according to methodical approaches are developed . Next in part there is scientific literature analysis based on geotechnical modeling and zoning according to foreign and local experience is generalized , from which then offer done modeling algorithm and In the case of Fergana region taken results in detail discussion will be done .

LITERATURE ANALYSIS

Literature analysis this shows that geotechnical features territorial modeling and zoning today's on the day geotechnics , geoinformatics and seismology intersection at the point formed large scientific from directions International experience first of all kriging and other geostatistician methods used without geotechnical parameters regional maps by to compose For example , Arshid and co-authors geotechnical parameters using kriging spatial interpolation so , electronically geodata to the base loading regional geotechnical based developed maps and the kriging method geotechnical in mapping other interpolation to the methods relatively more efficient that it is Ali and co-authors by collapse (collapsing) grunts spread probability cartographic in evaluation geostatistician approach applied , geotechnical parameters (humidity , density , collapse) tendency indicators) probability maps is made , this and geotechnical the danger territorial in evaluation statistic modeling advantages obvious manifestation will reach .

Last in years soil and regional modeling of soil properties according to geostatistician developments noticeable developed . Wani and co-authors various soil parameters based on ordinary kriging modeling , MSE and RMSE indicators using maps accuracy evaluated and kriging soil properties spatial in evaluation efficiency based on given by Hosseini and others kriging, cokriging and regression kriging methods compare , helper data (remote probing

images , height , precipitation , slope and others) add through spatial forecast accuracy noticeable improvement those who showed . Last in the works geostatistics and mechanical education attention to integration intensifying is going on : via kriging from the " spatial lag" features obtained mechanical education models enrichment through soil properties according to high accurate maps to take possibility offer This is being done . approaches content Fergana region soils geostatistics in modeling as well and GIS -based complex models application the necessity shows .

Geotechnical zoning and seismic microzoning according to literature geological , seismological and geotechnical information integrated without use the necessity emphasizes . Nath and co-authors seismic risk assessment according to microzoning in the model geology , geomorphology , seismic sources , ground dynamic properties and land under like the state of the waters factors complex into account recipient methodology offer did , then geotechnical parameters microzoning inseparable structural part as is considered . By Ansal cited modern microzoning according to in the comment and geotechnical research , website answer modeling and GIS -based many layered analysis microzonation main areas of work as shown . AHP, evaluation coefficients and GIS integration relied on geotechnical microzonation There are also jobs : for example , in Ethiopia Located in Shire- Endasilasie city for geotechnical microzonation maps slope , soil type , swelling potential and land under waters level such as factors in a GIS environment integration and Analytical Hierarchy Process based on weight coefficients determination through created . Also in New Zealand liquefaction danger GIS -based zoning geological developments screening , alluvial of beds spread , land under water level and seismic downloads integration relied on without done increased .

Geotechnical modeling normative approaches with harmonization , especially Eurocode 7 concepts with Binding is also used in literature. separately direction as Eurocode 7 (EN 1997-1) geotechnical soil parameters in design characteristic value selection , partial security coefficients and limit states method to use mandatory requirement , geotechnical of parameters probability and statistics point of view from the point of view to be evaluated in mind holds Orr, "Geotechnical education and Eurocode 7" and "The Concepts of Eurocode 7 for Harmonized Geotechnical Design" in their work of parameters characteristic value determination , reliability level and partially security coefficients meaning deep illuminated , geotechnical parameters based on GIS modeling in the process , this conceptual approach out of consideration aside not to leave need It is taught . This is In turn , for the Fergana region to be created geotechnical model and zoning maps not only of parameters spatial distribution , maybe their reliability and security also reflects the level to represent the necessity shows .

Fergana valley and By Fergana region take visited research mainly geological processes , neotectonics , relief and landscapes to study aimed at although , this GIS technologies in work application according to important experience gathered . Fergana valley geological processes , tectonic structure and neotectonic development according to take visited in research of the valley activity , sediment thickness , tectonic blocks movement and seismic zoning for basis divisor neotectonic maps structured . Landscape-ecological to zone dedicated in the works Fergana valley hills according to relief , soil , vegetation cover and natural and geographical factors integration based on landscape zones separated this is territorial zoning methodical basics geotechnical zoning as an analogue for useful to be possible .

Fergana based on GIS in the region electronic atlases , interactive-dynamic maps and digital relief models create also in order scientific affairs available . Khakimova and co-authors ArcGIS , QGIS and for Fergana region other programs based on information base create , electronic cartographic modeling and analytical mapping processes improvement according to results presented Khakimova , Abdukhalilov , Qosimov and others' For Fergana region creating interactive-dynamic internet maps according to ArcGIS Online and cloud from technologies using various thematic layers integration , user for comfortable web maps create methodology has been developed . Fergana valley southern part in the GIS “PANORAMA” environment for digital relief model create according to in the works and topographic maps based on accurate DEM generation , relief parameters calculation and them various fields (including geological and geotechnical analyses) application opportunities is illuminated . This affairs geotechnical zoning for necessary was cartographic and GIS infrastructure in formation support role plays . Uzbekistan GIS technologies for land resources , population points of interest and ecological in monitoring to use dedicated The work is also geotechnical. modeling for methodical basis creates . For example , Abboskhonovich and co-authors by GIS technologies population points from their lands use and monitoring effectiveness in increasing application according to cited examples geotechnical parameters base territorial planning tasks with tie opportunity shows . Fergana valley according to land structure , LULC change , tourism potential based on GIS to evaluate aimed at work is also kind thematic layers one to the system to combine them assessment indicators through zoning opportunities open gives .

With this together , geotechnical parameters spatial modeling according to directly geotechnical bases to create aimed at foreign There are also works . Arshid and based on co-authors' kriging electronic geotechnical information to the base regional geotechnical based mapping according to works , Ali and others' collapse grunts probability by kriging assessment experience , geostatistics cockfighting and other methods geotechnical to the information implementation to grow according to affairs Similar for Fergana region the need to develop an approach shows . The main difference here is is that for the Fergana region geotechnical model Europe or other regions designed for correlations blind - blind acceptance without doing , exactly local field and laboratory tests to the results Relying on the requirements of Eurocode 7 and customized in a way use need It will be .

In general generally , literature analysis this shows that geotechnical features modeling and zoning according to progressive experience in three main directions aggregate :

(1) kriging and other geostatistician methods based on parameters mapping ;

(2) GIS -based many layered , integrated geotechnical and seismic microzonation models ;

(3) Eurocode 7 and probability approaches suitable accordingly of parameters safe and reliable design values acceptance .

By Fergana region there is geological , geomorphological , landscape-ecological and GIS research and territorial geotechnical modeling for strong cartographic and methodical foundation creates . Therefore Fergana region soils geotechnical modeling and zoning concept exactly this international approaches and local GIS experience to the synthesis based development without to the goal is appropriate .

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RESULTS AND DISCUSSION

This research within Soils of the Fergana region modeling geotechnical properties and the area geotechnical in terms of zoning according to taken results this showed that the previous developed in sections (2.1 and 2.2) field laboratory methodology and accounting parameters determination concept of GIS and geostatistician approaches with harmony territorial assessment quality noticeable at the level increases . First of all , Fergana of the province various in the districts located wells , geotechnical points and sections according to gathered field and laboratory results geotechnical information base in appearance created : every for a point coordinates (X, Y, Z), layer code , grunt type , test types , experience values (X_test), characteristic (X_k) and computational (X_d) parameters , as well as to regulatory and legal documents links with together digitized . Data base such structured shape next modeling stage noticeable at the level simplify and import parameters into a GIS environment straight away integration opportunity gave .

Information base Imported into GIS without , φ , c, E, g , Cc, cv, Dr such as basic geotechnical parameters for separately point layers was formed . Each parameter according to known depth ranges – for example , 0–5 m and 5–10 m – separately Perform spatial analysis increase their vertical according to taking into account the change to take opportunity gave . Results this showed that the region alluvial plain in zones , especially large river valleys and irrigated arrays around , above humidity and salinization as a result φ and c values some in the plots noticeable at the level reduced , deformed parameters while (E, Cc) is negative towards ag' gan . Percentage and statistic indicators this showed that Fergana valley central part and some low in the regions φ of characteristic value known depths according to average 10–15% lower than the background , and E is 15–20% smaller to be This is possible . irrigation under the circumstances salty and structure broken of the ground spread with explained .

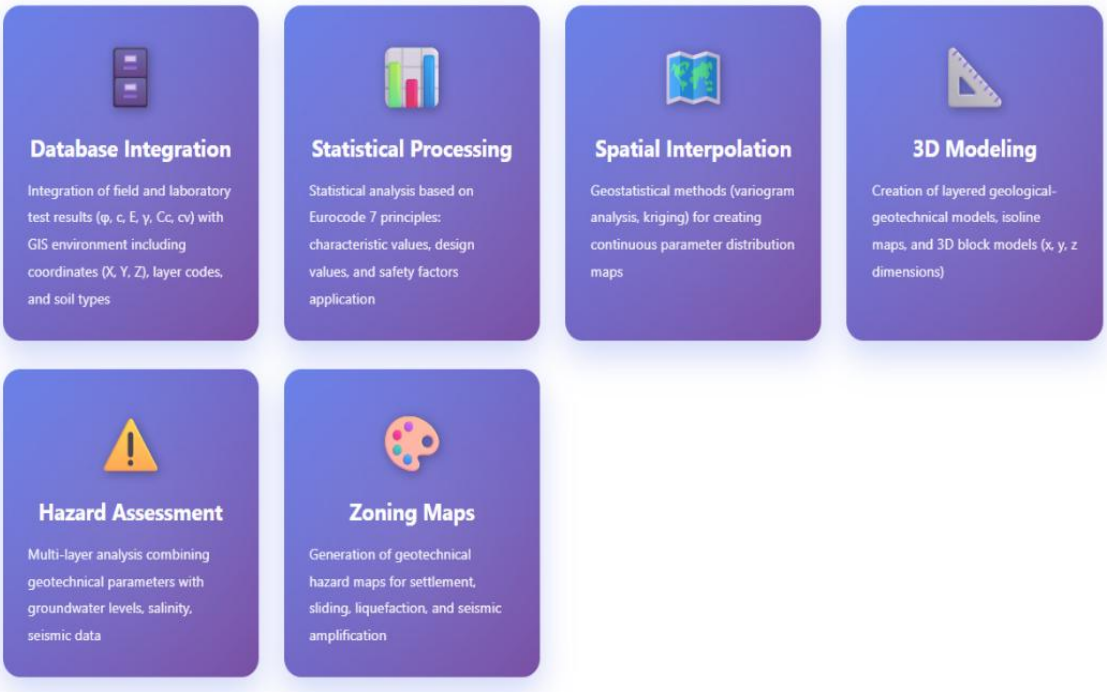

Figure 1. Geotechnical Modeling Process

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Geostatistics modeling kriging type in the stage interpolation methods used . Parameters according to variogram analysis their spatial correlation (autocorrelation) distance) about information giving , interpolation the results reliable to evaluate help For example , drier and relatively stable granulometric to the content has sandy – sandy in the fields φ and E parameters according to spatial autocorrelation distance bigger to be , to be less on the thigh points enough on the basis of smooth parameter area to take possibility On the contrary , loess and salty grunts column was in the regions , and tectonic cracks near dispersion high happened because of variograms more uncertain , autocorrelation distance and smaller to be came out ; this and this in zones more field points and deepened tests are required shows . On this basis geotechnical research size differential planning opportunity appearance became : geostatistician modeling to the results " safe " and " complex " zones according to separated , their every one for field and laboratory minimum necessary work number according to recommendations were developed .

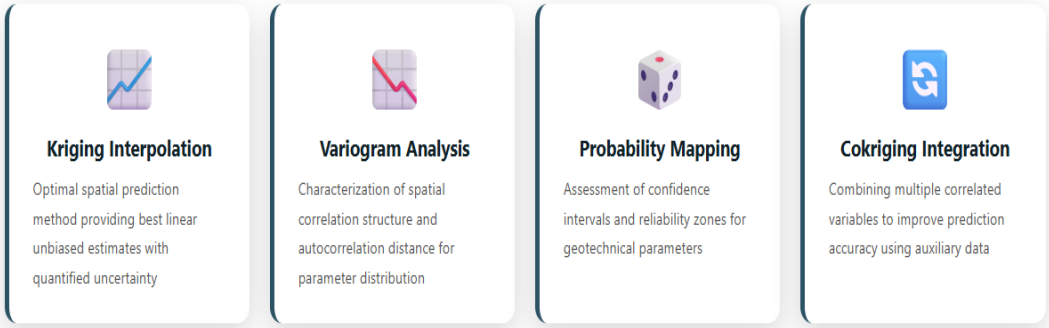

Figure 2. Geostatistical Methods Applied

Modeling as a result φ , c, E as parameters according to isoline maps and colored heatmaps This was taken . maps visual analysis is showed that the region along geotechnical conditions one kind not , maybe one how many to oneself typical to subzones For example , weak to salt has , relatively dense sandy – sandy grunts column was in the regions φ values higher , and E is average - high in between to be , to give weight to the foundation in terms of comfortable conditions There are such areas construction for " relatively " comfortable as a "geotechnical zone" On the contrary , irrigated arrays and collector-drainage networks under the influence strong soaked , salted and collapsing to the feature has grunts column was in the regions φ and E values low , Cc and cv parameters and inconvenient (larger) compression and variable consolidation) values record They are called " geotechnical in terms of as a " complex zone" separated . Analyses this showed that such in zones of the basics a person and differential sink danger high be constructive in solutions additional caution measures (deep foundation , foundations reinforcement , drainage , preloading and etc.) see necessary .

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Table 1 By Fergana region geotechnical zones description

No.	Geotechnical zone name	Basic geotechnical properties (φ , c, E, Cc, cv)	Geotechnical danger level	Recommendation attainable approach
1	Convenient geotechnical zone	φ and E relative high , Cc and cv low; grunts dense and stable	Low	Standard research program; shallow foundations , typical fittings reserves enough
2	Cautious approach zone	φ and E are average , Cc and cv are average - high ; humidity and salinity variable	Medium	Additional field tests (SPT/CPT), metallab tests ; foundation depth caution with choice
3	Geotechnical in terms of complicated zone	φ and E low, Cc and cv high ; collapsing , saline and wet grunts	High / very high	Deep foundation , ground reinforcement , drainage , preloading; expanded geotechnical research

In modeling, such as Cc, cv , and m_0 parameters spatially distribution maps These parameters are especially important for sedimentation . and far term deformations forecast in doing solution doer importance has . Results this showed that some slope zones and old alluvial Cc values on terraces relatively low, this on the ground of the ground compression potential limited and stronger to be , to sink danger big Not . Water- absorbing low regions , old swamps , river tall accumulative in the zones and the values of Cc and m_0 height it is determined that in the regions constructive solutions when choosing sink forecast separately caution with done increase need highlighted . cv parameter spatial map and consolidation processes speed according to territorial the differences showing gave : cv was low in zones sink far term continue to be able to , this and building exploitation initial in stages deformations continuous to be possible indicates .

GIS environment soil parameters not only separately on maps , maybe other thematic layers with opportunity for joint analysis For example , φ and E maps with one at the time land under water level , salinity level , relief slope , seismic zoning maps , engineering and geological zoning information one into layers placed , many Perform a layered analysis increased . As a result geotechnical danger (subsidence , liquefaction , sliding and seismic to the level of reinforcement see complex assessment system was formed . On this basis Fergana region territory conditional accordingly one how many geotechnical to zones separated : relatively comfortable zone (parameters stable , sinking and seismic low risk), cautious zone where the approach is required (parameters average , but hydrogeological or seismic conditions complex), and geotechnical in terms of complex zone (parameters uncomfortable , salinity , collapse , high land under waters and seismic factors together impact For each zone recommendation attainable geotechnical search size , test types and constructive solutions according to general recommendations were developed .

Seismogeotechnics point of view from the point of view take visited analyses are also important the results showed . Grounds dynamic properties (e.g. Vs, E din, damping coefficients) information there is was in the regions this parameters φ , c, E and other static parameters maps with were analyzed together . As a result seismic waves slow , gentle and wet layers column was in zones dynamic reinforcement probability high to be , that's it with together collapsing

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and liquefaction danger there is to be possibility determined , such regions separate " seismogeotechnical" as a "danger zone" These zones are marked . for seismogeotechnics in calculations harder design requirements , additional seismic reinforcement measures and deeper geotechnical research recommendation was done .

Research of the results practical importance in evaluation geotechnical modeling and zoning of the results in the design to the role separately attention Geotechnical information base and GIS maps using designer engineers known plot grunt parameters for in hand looking for find instead of interactive on the map him/her select and at this point φ , c, E, γ and other of parameters characteristic and accounting values , additional accordingly to zone related geotechnical recommendations one instantly see as much as possible has This approach will be design time shortens , human factor with related mistakes reduces and geotechnical in calculations parameters choice process transparent and interpretable does . Also, the data base updated going to nature has to be done – new wells , tests and projects information regular adding go – time passing with models accuracy and reliability to increase service does ..

Figure 3. Modeling Workflow

Regional geotechnical modeling results also showed that Fergana in the province some in places in practice using upcoming " organized " approaches known at the level again seeing to exit need . For example , traditional accordingly considered stable some in zones (soil above cover (by) depth according to geotechnical parameters when modeled , known average from the depths below lying down soft , moist and salty layers determined and they of the basics far term a person and seismic in response noticeable impact to be able possibility obvious On the contrary , some considered difficult in zones Fergana relief , drainage and hydrogeological conditions into account when taken parameters enough stable was The fields were also divided ; this on the ground probable excess conservatism reduce , economic in terms of approved constructive solutions choice opportunities appearance It will be .

In general when taking , the results Soils of the Fergana region modeling geotechnical properties and zoning designed for approach efficiency confirmed . Field and laboratory tests the results statistic again performance , Eurocode 7 principles suitable accounting parameters to determine , then them GIS and geostatistician methods based on spatial modeling through territorial A geotechnical model was created . Based on this model geotechnical and seismogeotechnics risk to the level see zoning done increased , construction and infrastructure projects in planning use possible was practical maps and recommendations package was formed . The results scientific novelty is that geotechnical parameters first times At the level of Fergana region complex as a field laboratory data , statistical analysis, Eurocode 7 approach and GIS

integration in harmony – modeled ; practical importance and in the province stable , safe and economic in terms of effective construction solutions when choosing engineering decisions further reasonable It's in the making .

CONCLUSION

This in research Soils of the Fergana region modeling geotechnical properties and the area geotechnical risk to the level see zoning a single conceptual framework for and practical approach was developed . First of all, the field and laboratory tests the results (φ , c, E, g , Cc, cv, Dr and others) systematic in a way collect them statistic again work and Eurocode 7 requirements based on characteristic and accounting values determination principles based on geotechnical information base was formed . Then this information database to GIS environment integration geostatistics methods (variogram analysis , kriging and using hk) of parameters spatial distribution modeling , isoline and superficial maps in appearance visual expression opportunity created . Results By Fergana region of the ground geotechnical features sharp one kind not , but alluvial plains , irrigated salty fields , loess and collapsing regions in the middle noticeable differences existence clear showed .

Geostatistics modeling as a result Like φ , c, E, Cc, cv parameters by region dispersion quantitative estimated , autocorrelation distances which is determined in zones field tests number reduction or on the contrary multiplication necessity according to scientific based conclusions was obtained in a GIS environment . geotechnical parameters layers land under waters level , salinity , relief slope , seismic zoning and other thematic layers with analyzed together , geotechnical and seismogeotechnics risk level according to complex assessment done was increased . On this basis Fergana in the province relatively comfortable , careful approach required and geotechnical in terms of complicated zones separated ; each for one zone of the basics earthquake , stability , seismic answer and application necessary was constructive and technological solutions according to general recommendations were developed .

The research scientific novelty The fact is that the Fergana region is geotechnical conditions first there is complex in a field-laboratory manner tests , statistical analysis, Eurocode 7 concept , geostatistics modeling and GIS technologies in harmony – modeled and geotechnical zoning done increased . Practical importance and is that it was created geotechnical information base and zoning maps design in the process parameters to choose accelerates , human to the factor related mistakes reduces , research size territorial risk to the level looking at to optimize opportunity gives and Fergana in the province sustainable , seismogeotechnical requirements and economic to the criteria suitable construction solutions to choose service does . As a result offer done modeling and zoning approach not only separately projects , maybe province on a scale territorial planning and infrastructure development scientific based geotechnical platform to form ground creates .

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