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ウズベキスタン国地すべりモニタリング  
技術向上支援プロジェクト

プロジェクト事業完了報告書  
巻末資料

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## 1. C/Pによる地すべり解析レポート

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Distinctive large modern landslide, which developing within the old landslide scarp is a block type Tekstilshik Landslide, located on the left side of Chirchik River.

Modern landslide displacements are developed slope down on 1,4 – 1,5 km and with width 500 m in upper and 250 – 300 m in lower zone. Specific structure of the landslide is its separation into two parts in the middle part of the landslide with graben formation where the line of Alizar failure is passed. The landslide on upper and middle part consisted of 20 – 30 m of loess layer, lower its decreased up to 5,0 m. Mild clay underplayed by interbedded chalk formations, clays, aleurolites, sandstones, gravelites with capacity of each layer 2 – 4 m, the interchange of the lithological differences occurs on depth up to 100 m and more.

First modern processes within the old landslide body occurred in 1996 as an erosion cone along highway in front of children's health camp. Large deformations occurred in spring 1996. In the middle and low part the crack of 500 m extension has been formed, lower the slope in the distance of 200 – 250 m new cracks were also observed in length of 50 – 55 m.

From 1973 the head crack moved to the scarp of 5 – 12 m height and over it on gently inclined surface another big crack of 500 – 540 m extension has developed, with 0,8 – 1,2 m of vertical movement value.

On 6<sup>th</sup> of April 1979, secondary movement with volume more than 20,0 mln. m<sup>3</sup> occurred. The movement covered loess and sandy-clay chalk formations with capacity more than 40 m, of extension 1320 m and of width 400 m. Landslide developed bottom-up. The second block characterized as graben depression, located upper than first on 70 m distance. There are numerous cracks of different shape. Landslide mass movement was directed to lowered part of valley, where impounding lakes were formed. Numerous cracks with reverse displacement altitude inside graben depression and reverse movement direction up to the slope were formed. The graben depression divided landslide into two parts lower and upper part. In 1979 lower part of the landslide developed more active.



The biggest movements occurred on 18<sup>th</sup> April 2003, in upper part of the landslide. The length of the upper crack on the right flank increased up to 500 m and on the left up to 130 – 150 m. In the head part of the landslide vertical deformation on 0,3 – 1,0 m occurred. Total length of the scarp reached 1,1 km with total altitude up to 3,0 m. The landslide block on the right flank of 0,2 mln. m<sup>3</sup> volume has moved, in the middle part the landslide moved on 50 – 60 m with volume of 1,0 mln m<sup>3</sup>, and partially destroyed highway. In 2005 vertical deformations 1,17-2,15 m in the upper part and 12,9 m in the middle part occurred.

Thus, the Tekstilshik landslide is developing during 45 years, within the old landslide scarp; it's related to varied conditions of slope watering.



Within the frame of JICA Project, the first works were started on the landslide site using drilling machine YBM-IWA, 4 boreholes were drilled (first borehole upper than scarp, 60 m in depth, second borehole in the upper part on the landslide step, 45 m in depth, and third borehole 30 m in depth) to control ground water level automatically, and fourth borehole 45 m in depth in the central part of the landslide in Alizar failure zone.

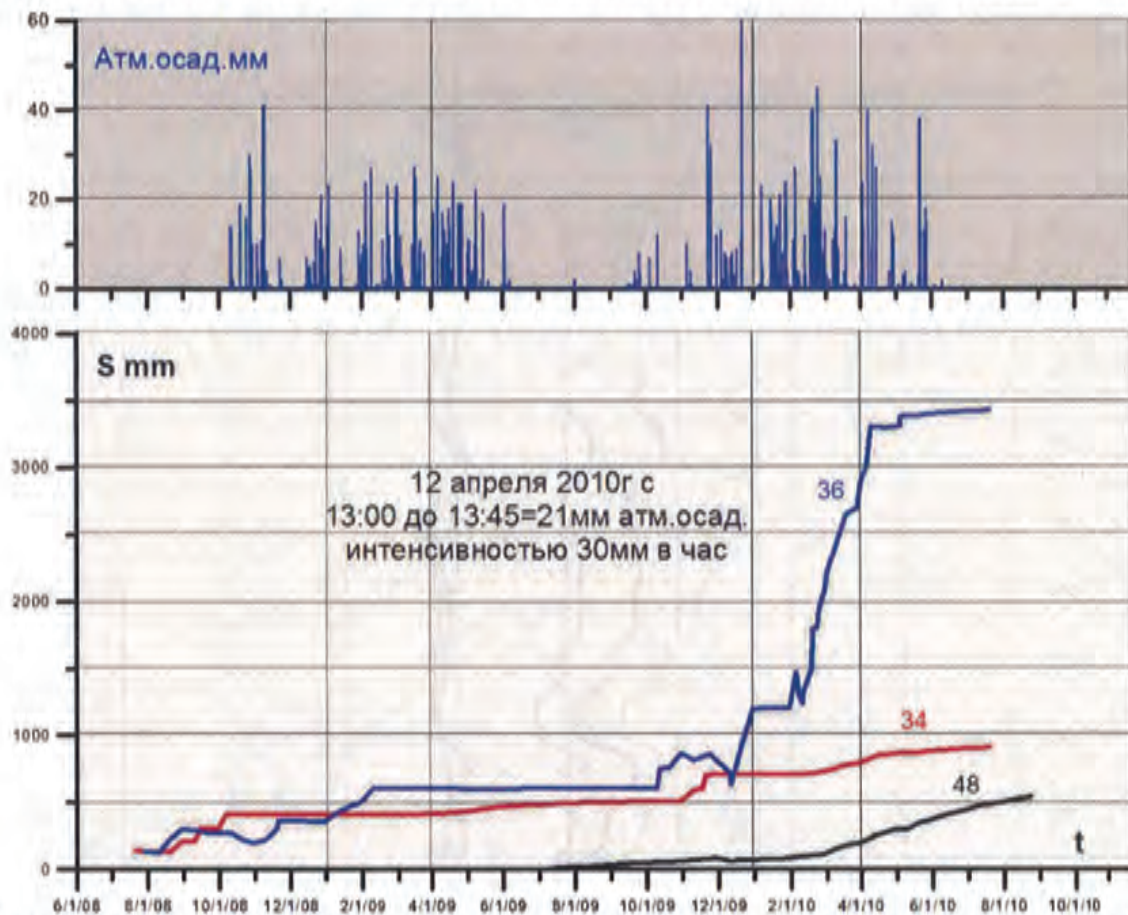
### Geophysical works results VES.

Field investigations were implemented by using electric sounding machine McOHM-EL. Based on geo resistance the geological-geophysical cross section was prepared. In the lower part extent chalk formations, sandstones with aleurolites interlayer, and in the upper part the mild clay formations bedded. On the central part of the landslide, where second borehole is located, assumed sliding plane is observed, that due to water saturation of soil typical for low geoelectric resistance. It's confirmed by inclinometer results.





The observations using Extensometer were started from 7<sup>th</sup> July, 2008 and continued until today for Ext. 48, 34 , 36, within 24 month. Two Extensometers, where one long span and one ground type were destroyed in spring 2009 due to soil moisture and liquefaction in graben like deep cracks zones. Remaining third

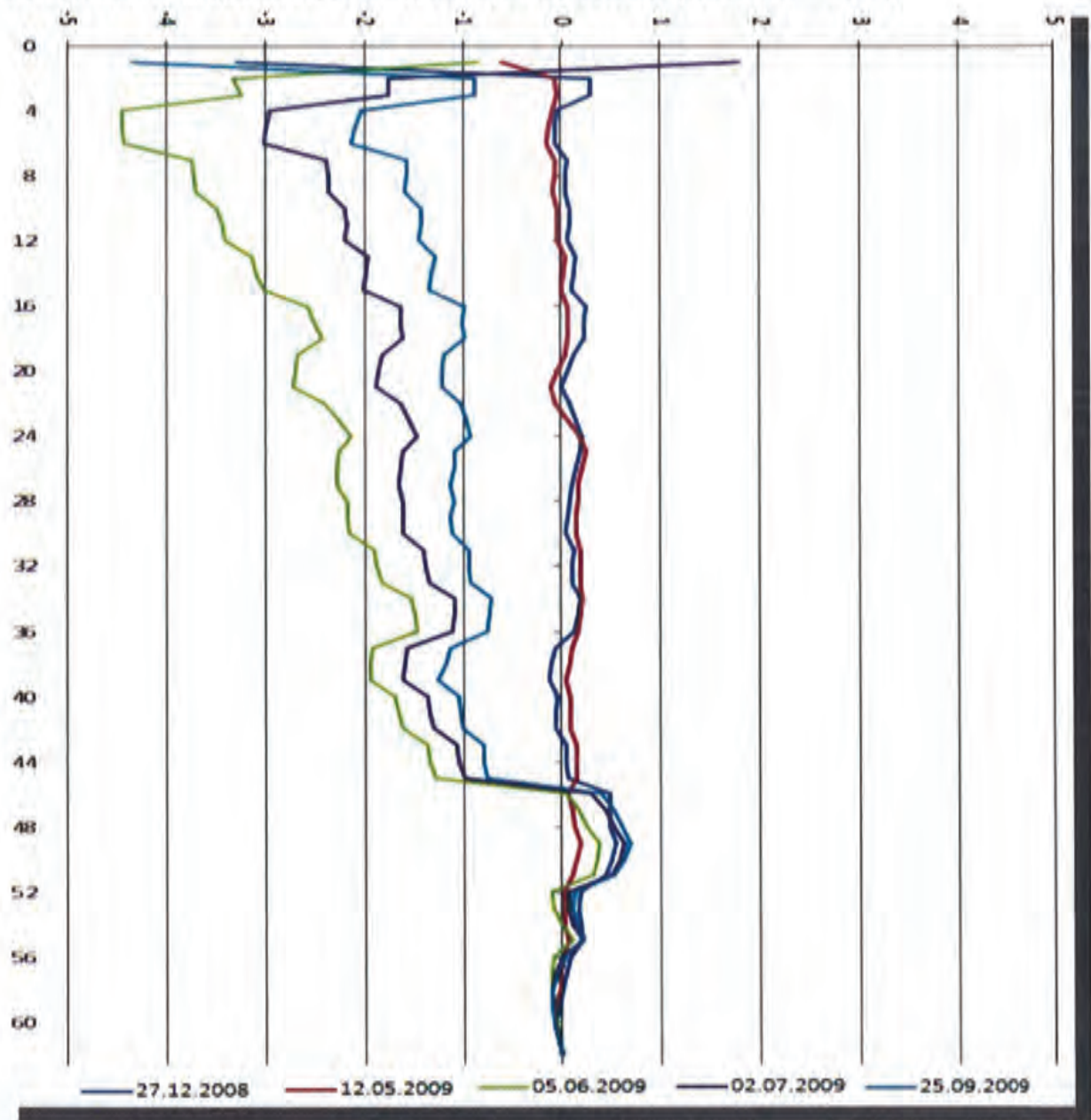


Extensometer installed in the upper part shows that in the landslide scarp area (Ext. 48) the smallest displacement is up to 50 sm., that appeared in Spring 2002, in different years 2008 – 2009, the landslide movement was not observed. The landslide step lower than highway more active, where boreholes and Extensometer 34 installed. There were landslide displacements up to 50 cm. in 2008 – 2009 and speed acceleration occurred in spring 2010. Total displacement value reached 1,0 m.

However, the biggest landslide displacement occurred under the graben depression up to 3,3 m. Meanwhile, the biggest soil movement occurred on 2 – 3 of March 2010 up to 20 cm, 18 – 19 of March 2010 – 12 cm, 12 of April – 26 cm. It's correlated with amount of precipitation in February 2010 – 280 mm, and on 12 of April was rainfall with intensity of 30 mm/h. When within 40 min (rainfall data) amount of precipitation reached 21 mm, the ground water level changed dramatically.

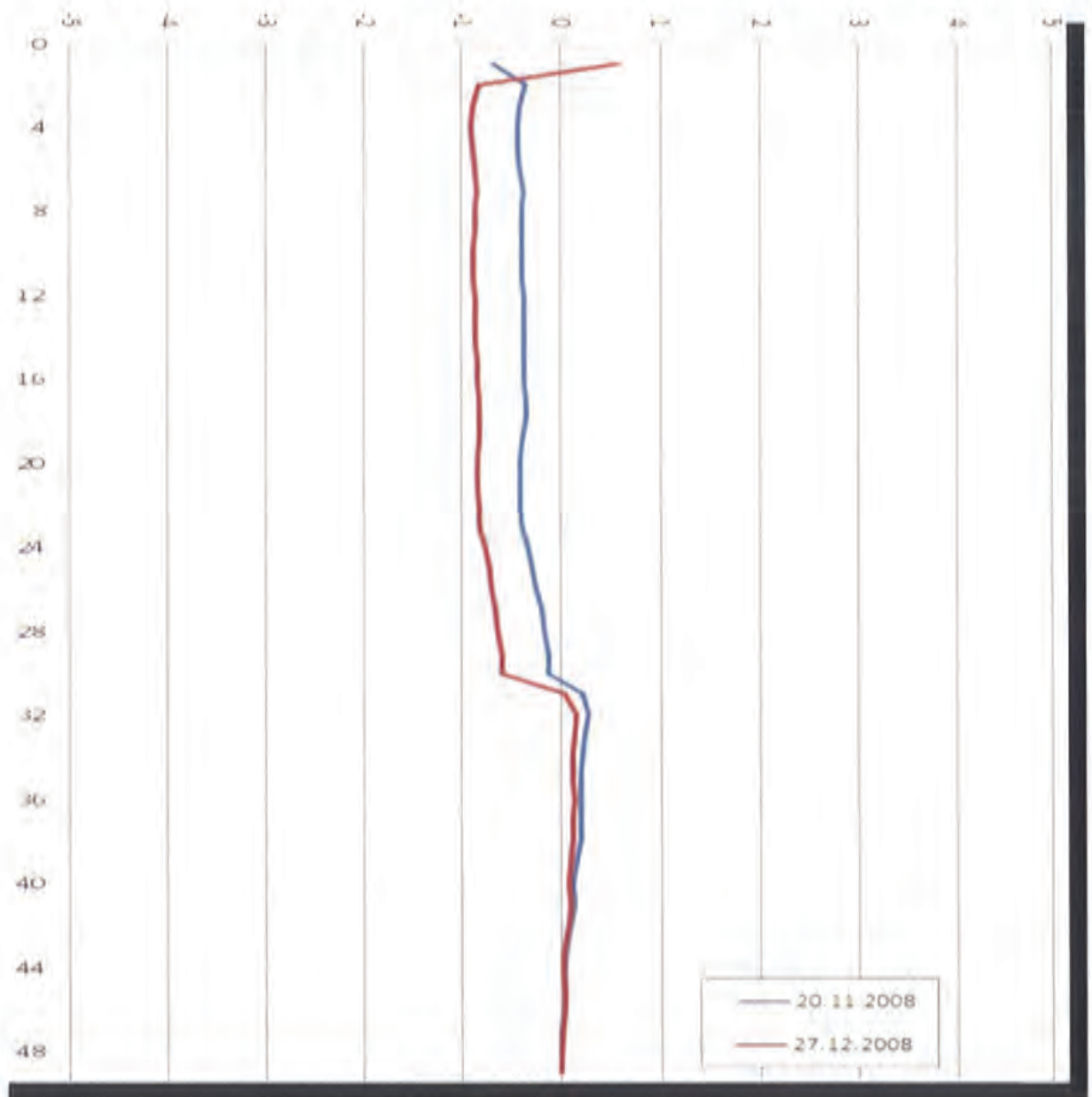
## Inclinometer results.

Inclinometer graph for borehole № 1, A directions (azimuth – 300°)



Borehole №1. Locates in the upper part of the site (upper than landslide scarp). The borehole was drilled on 09 of October 2008. The borehole depth is 60 m, 10 cycle measurements were implemented. Annual cycle measurement shows that measurement values closer to the surface differ on 4 mm from initial. On the depth of 45 m, clearly defined the graph cut and it's considered as border of assumed sliding plane.

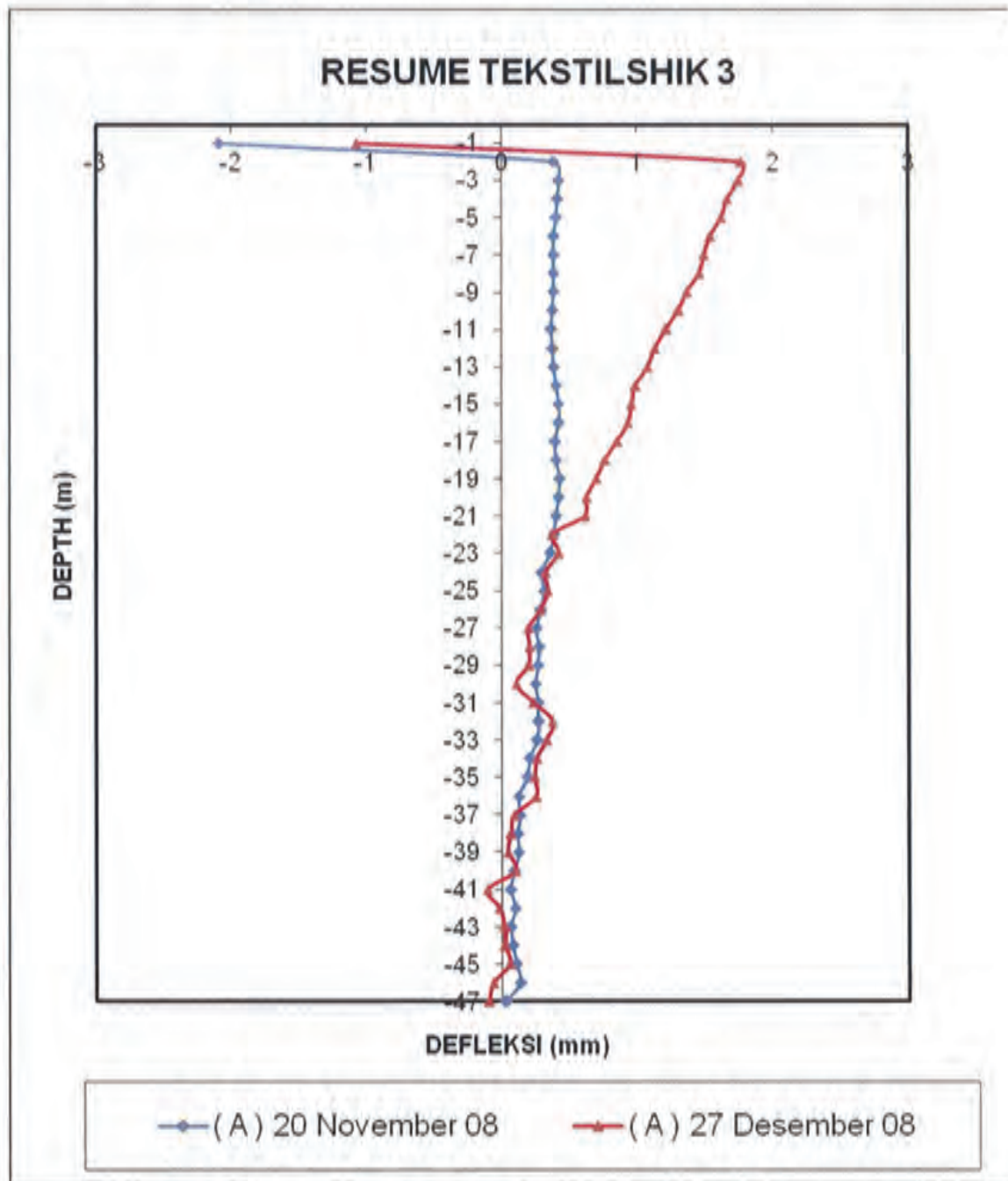
Inclinometer graph for borehole № 2, A directions (azimuth - 270°)



Borehole №2. Locates in the central part of the landslide. Drilled on 09 of October 2008. The borehole depth is 47 m, 7 cycle measurements were implemented. On the graph from the surface to 30 m depth big change is observed (aprox. 0,5 mm per month), unfortunately this year was impossible to implement measurements in winter time (because of sever cold and snowfall).

In spring time when measurement, the Inclinometer electrode putted down on 29 m depth, that give evidence of soil displacement. Received but not processed data shows that sliding plane is on 27 to 31 m depth.

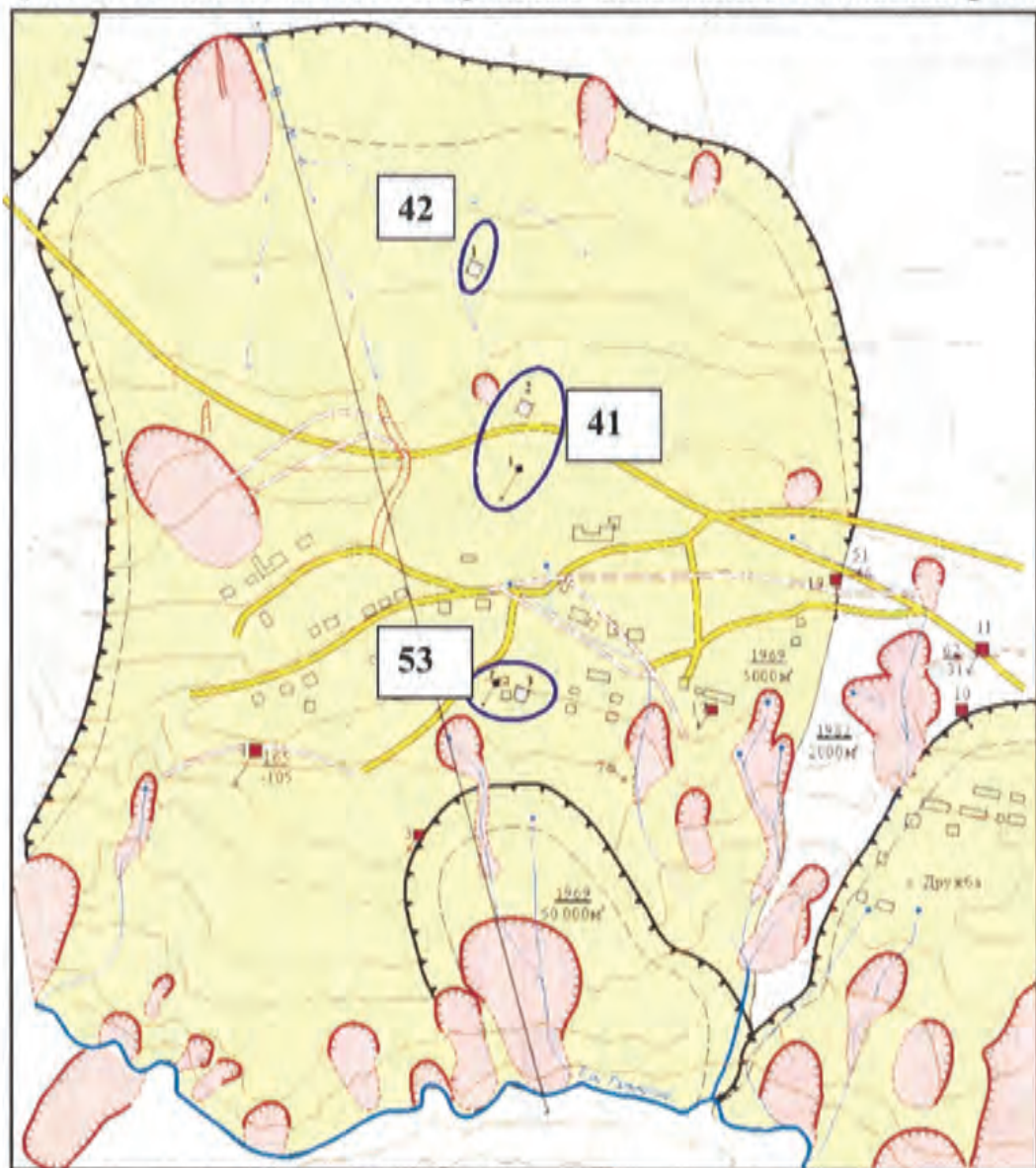
Inclinometer graph for borehole № 3, A directions (azimuth – 360°)



Borehole №3. Locates in the lower part of the landslide. Drilled on 09 of October 2008. The borehole depth is 47 m, 2 cycle measurements were implemented. In the borehole on 2 m in depth, the changes of 1 mm per month occurred, in spring time the borehole was stuck by clay on the depth.

**The old landslide Uchterek** of about 100 mln. m<sup>3</sup> volume, of 1800 m extension, of 1 km in width, and 40 – 60 m capacity, its formation related to water saturation of soils and seismic impacts.

In 1994 after the earthquake on 2 – 3 of May, in Uchterek village new cracks of 1,2 - 1,5 km extension appeared. In the houses the through cracks and distractions appeared. The cracks appeared only in the side borders of the landslide, and in the middle part were not observed. The geodetic observations results using reference

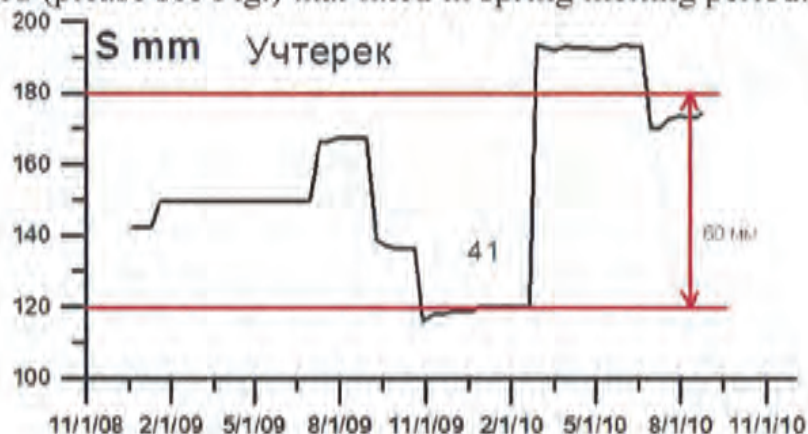


points, implemented by Bostanlik MS showed that for the period from 2006 – 2008 the horizontal displacement reached 5,1 – 8,9 cm in Uchterek site. Development of the crack goes on at all times and is settled on highway paving asphalt. There are more than 40 households where more than 500 people live.

Due to social importance of the site three boreholes were drilled in 2008 (borehole.1,65m; 2-42 и 3-40m) for study of geological structure and hydrogeological conditions of Inclinometer observations in depth. At the same year three Extensometer were installed, first in the upper part of old

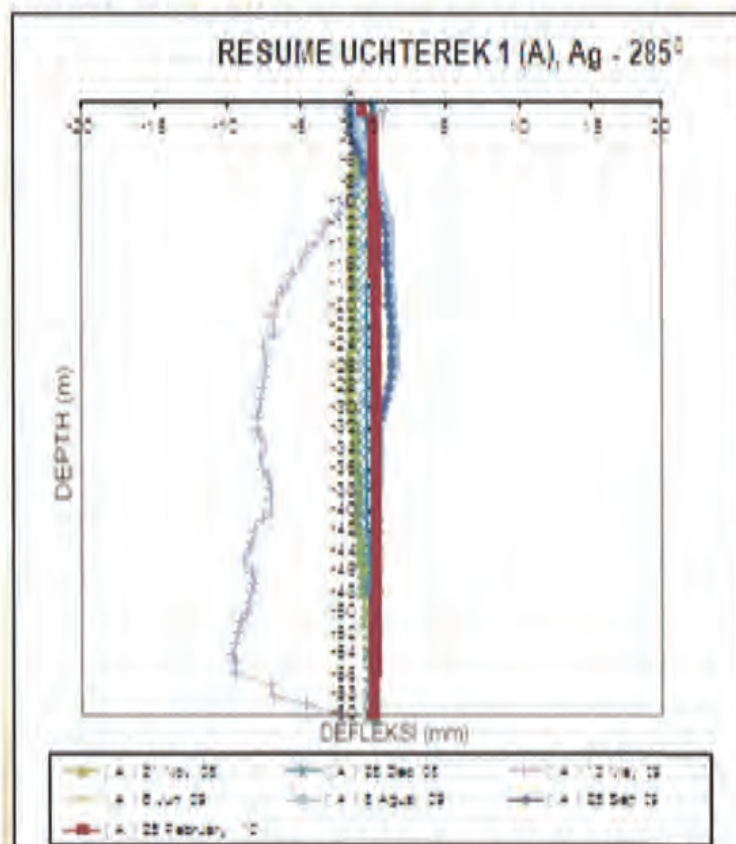
landslide(Ext.42); second – on cracks above the village (Ext-41) and third in the central part of the village (Ext.63).

Observation results for 2008-2009 showed, that in upper part and in the central part of the village the landslide movements were not observed, that's why the Extensometer-41 remains on the crack above the village and other Extensometers were removed to the other landslide sites. For the period from 2008 to 2010 for 21 month the Extensometer 41- insignificant displacements on 32 mm distance were observed (please see Fig.) that fixed in spring melting period.

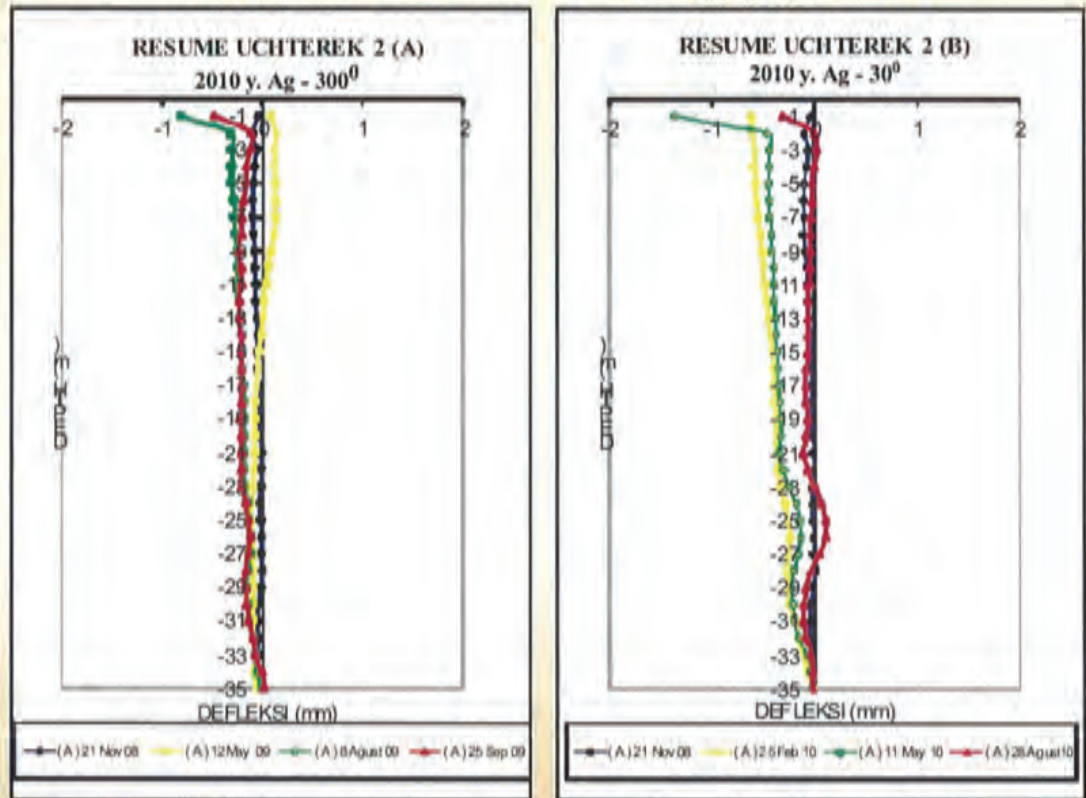


### Inclinometer results.

Borehole №1. Locates in the upper part of the site (150-200 m upper than Tashkent – Chingam highway). The borehole was drilled on 11 October 2008, 7 cycle measurements were implemented. On 13 of May 2009 movement within whole borehole depth were observed, during other cycles movements were not fixed.

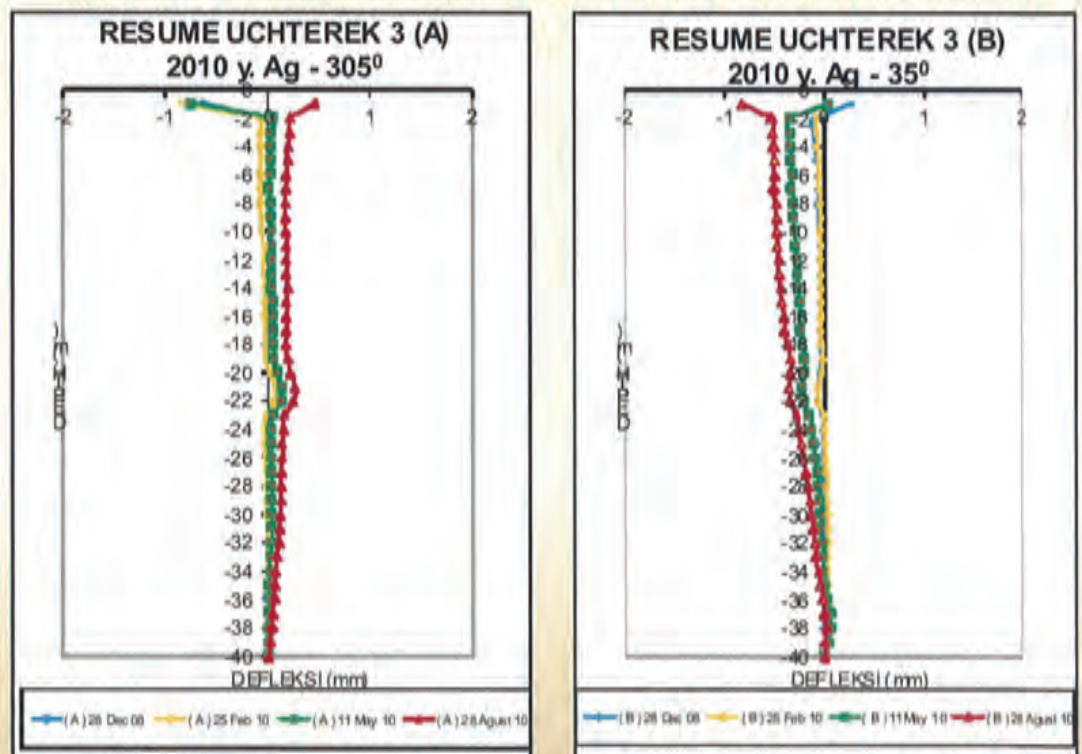


## График Инклинометрии Уч. Учтерек, скв.№2



Borehole №2. Locates along Tashkent – Chimgan highway. The borehole was drilled on 12 of October 2008. The borehole depth is 35 m, 10 cycle measurements were implemented. For the data received, seasonal changes value reaches up to 0,5 mm. Significant changes on depth are not observed.

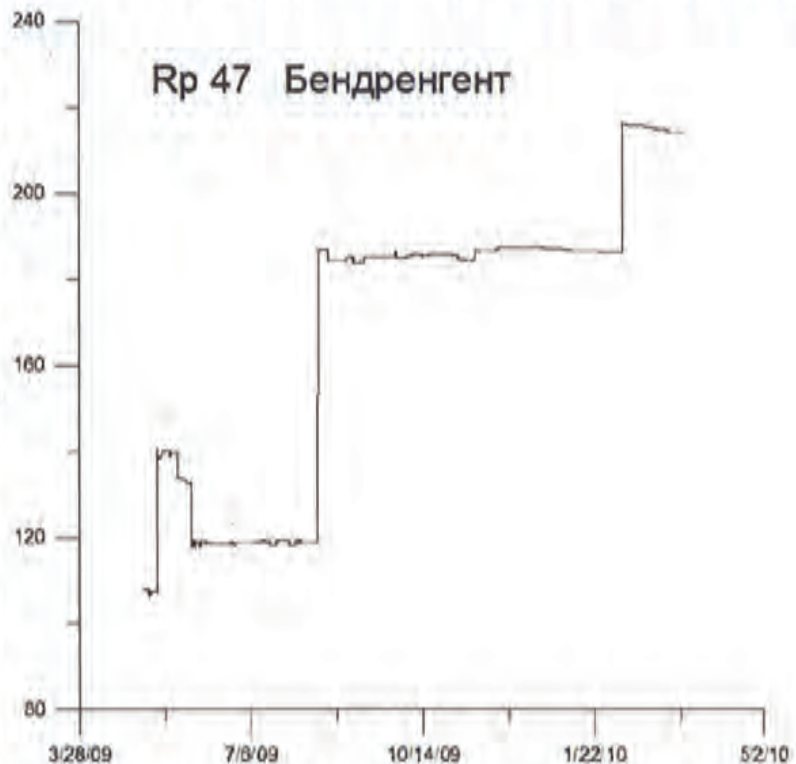
## График Инклинометрии Оползень Учтерек, скв.№3



Borehole №3. locates in the lower part of the landslide (near the living houses). Drilled on 15 November 2008. The borehole depth is 40 m, 9 cycle measurements were implemented. Based on the data received small change on depth of 20 to 22 m is observed, most probably its related to pipe expansion in depth.

Thus, observation data of Extensometer and Inclinometer shows that in general the landslide is in stable condition and it's not endanger the Uchterek village. Extensometer and Inclinometer observations are planned to continue in the future.

**Bedrenget Landslide** locates on the left side of Bedrengetsay of Nijbashsay right side stream. First cracks of 20 – 25 m in length formed in spring 1993 on the slope 35 – 40 m in height and 30o gradient. In spring 1994, the cracks increased in length up to 35 m. At present time length of head crack increased up to 45 m, altitude up to 0,5 m. Volume of possible displacement up to 25,0 t. m3. Two living houses located on the opposite slope are in danger. In May 2009 two Extensometers in central and right side of the crack were installed.



For Extensometer 47 installed in the central part of the crack for the period from 3 of May 2009 to 14 of March 2010 the displacement reached 107 mm for 16 month, confirms that crack is in active stage. Second Extensometer as far as it's located at a short distance was disassembled and removed to the other site. Observations for Extensometer 47 are planned to continue in the future.

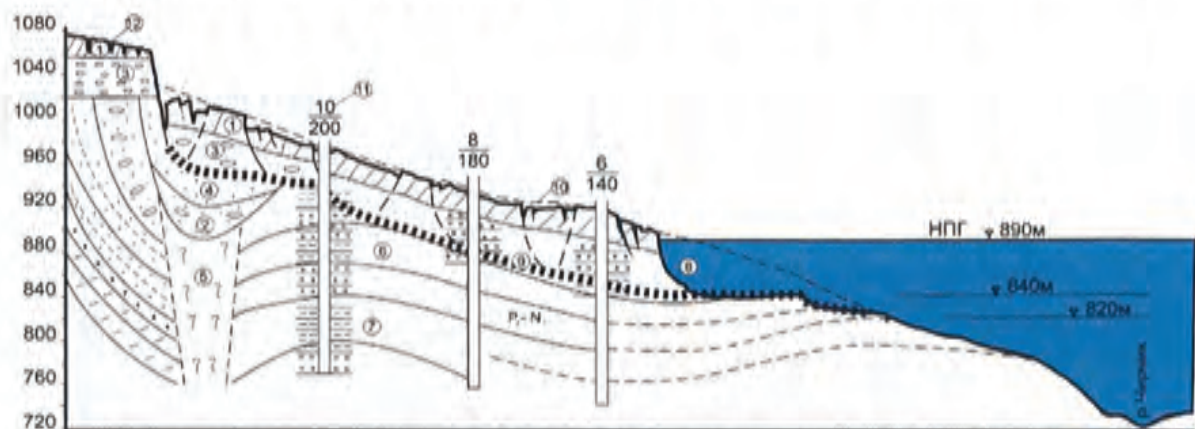


**Mingchukur Landslide** has 3 km width, 70 mln. m<sup>3</sup> volume, locates on left side of Charvak water reservoir in 3,5 km from damsite.

The most active is right side of the landslide, it's 780 m in length of it 420 m above maximum water level, and 360 m – in the fluctuation drawdown level with volume of 24,5 mln. m<sup>3</sup>. The slope consisted of surface conglomeratic-gravel stone with capacity of 5 – 20m covered by mild clays of 5 – 10 m. The thick neogene layer (N) bedded lower, it's presented by interlaid red aleurolites, sandstones, clays and gravelites.



Geologic-tectonic structure of the landslide caused by flexural-tensile zone of Pskem failure. Main fault passes in the basement of landslide scarp it has 10 – 12 m width. Assumed depth and shape of landslide sliding surface has been done by the results of drilling in 80-ies and inclination angles of surface reference points. At present time the steepness of sliding surface is 26-30° in upper part, 17° in the middle part and 4-6° in lower part.



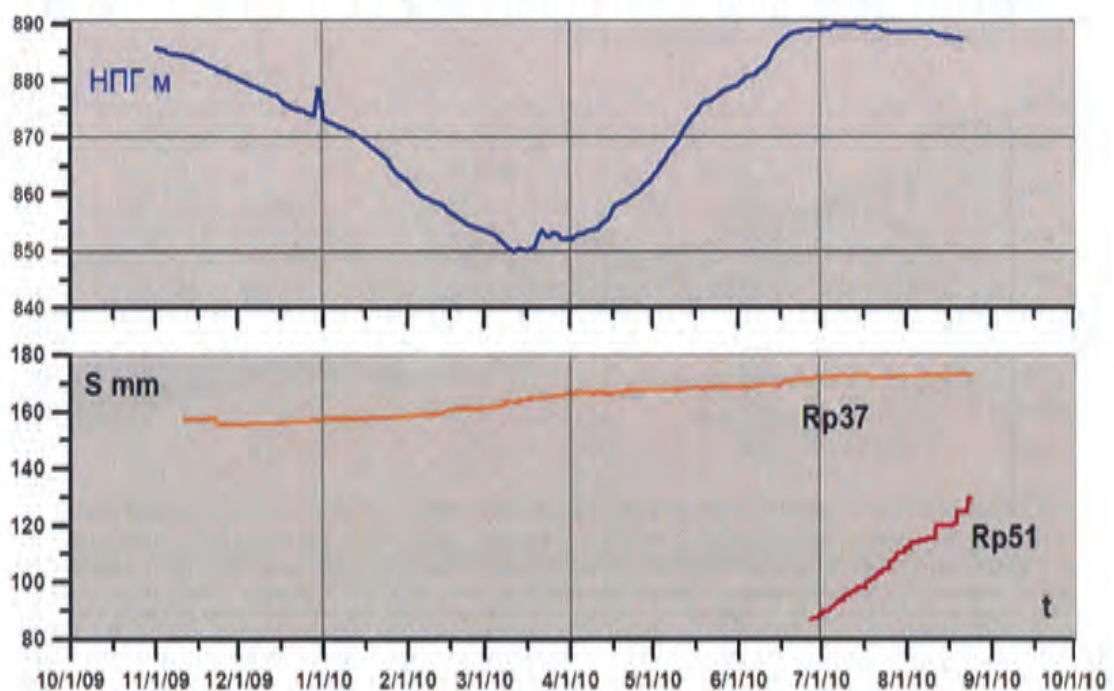
1. Лесовые породы с включением галечника; 2-гравий и галечник; 3-конгломераты; 4-переслаивание алевролита и песчаника; 5-зона тектонических нарушений; 6- переслаивание красноцветных глин, алевролита, песчаника и конгломерата; 7- переслаивание глин и песчаника; 8- зона оползня 6 августа 1082г.; 9- зона скольжения оползня; 10-поверхность склона до оползня ; 11-номер скважины и глубина ; 12-трещины 2004 -2009 г.г.

Activation of the old landslide was observed on 06 of August 1982, when the discharge of water level in water reservoir for 1981 and 1982 on 76 m as a result the landslide of 2,0 mln. m<sup>3</sup> volume was formed.

Its last activity observed from 21 of March to 12 of April 2004, value of horizontal movement reached 1,6 – 1,9 m, soils movement speed exceeded last cycle in 12 – 15 times. As a result upper than landslide scarp in 35 – 40 m from the edge the new crack (please see photo) more than 300 m extension and with altitude up to 1,0 m was formed. A feature of the active displacement was simultaneous movement of whole landslide massive, a division of the landslide into different generations has not happened.



Mingchukur Landslide Rp 37 (November 2009),Rp 51 (June 2010).

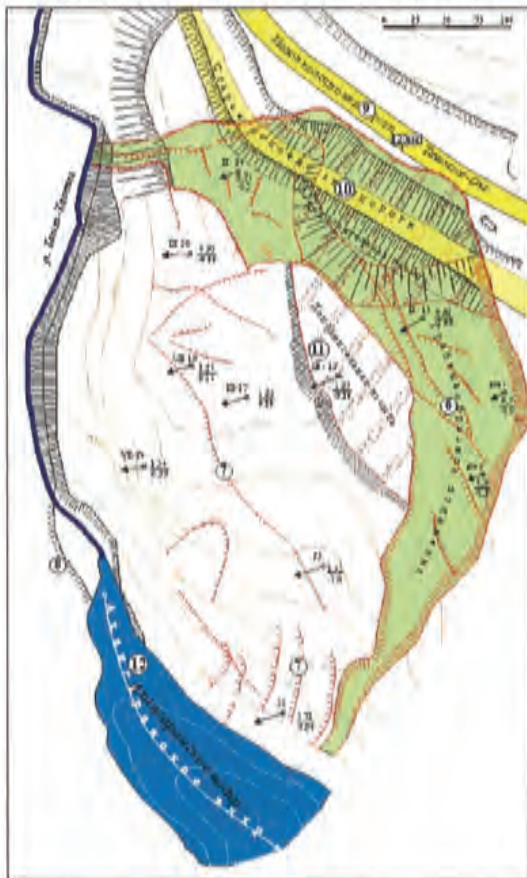


In 2008-2009 the biggest deformations occurred upper than landslide scarp, cracks extension reached 400 m, with altitude from 0,5 to 2,5 m assumed a circus shape, which side borders tracing on height of the landslide scarp, i.e there is a tendency of landslide increasing in upper zone.

On upper zone of Mingchukur landslide at the place of new crack formation two Extensometers were installed. Ground type Extensometer 37 was installed on 11 of November 2009 in the head part of the landslide. During ten month soil displacement was 16 mm only, very low movement value. After that the long span Extensometer 51 was installed on 21 – 22 m distance above graben depression. The Extensometer was installed on 26 of June 2010, for two month or 60 days (24 of August) movement in the area reached 43 mm  $V=0,7$  mm/day. Such installation of long span Extensometers above the graben cracks considered as more correct. Correlation of Extensometer data and level of discharged water in Charvak water reservoir showed no acceleration of landslide movement when elevation of water in water reservoir is low - 850 m.

In the future on Mingchukur landslide is planned to continue monitoring with the installation of 2 more extensometers in the central and lower part of the landslide.

**Tanga-Topdi Landslide** (120 km of Tashkent – Osh highway) locates on the right side of Ahangaran water reservoir, on the left side of Tangatopdi gully. First cracks of 40 m length formed in March 1987 on the slope lower than highway. These cracks started to form graben dip. At the same time on the highway roadbed formed curve crack delineated head part of the landslide. From 1987 to 1990 there formed impression type landslide with extension of 290 m and of 300 m in width. The landslide's movement covered highway roadbed on 160 m distance. In its upper part the graben of 50 – 80 m in width and 2 – 3 m altitude was formed. In the center of the low zone and on the right and left sides of the Tangatopdi gully the protrusion wall has been formed on 130 – 140 extension, of 1 – 1,5 m in height. The landslide sliding plane expected on Suzak clays and sands at a depth of 25 m or 40 – 45 m, the volume of the landslide is 2,5 mln. m<sup>3</sup>.



Sufficient landslide displacements occurred in 2001 – 2003, when movement speed increased from 0.3-1.6. mm/day to 8-34 mm/day. The most probably its related to the highway reconstruction works, when old highway was embanked and a new was moved up and expanded in two times and from one-way road the two-way highway was created, and the overburden was embanked into the graben dip of 4 – 7 m capacity. In 2005-2008 the low part of left side of the landslide moved more active, which confined to the water reservoir backwater zone.

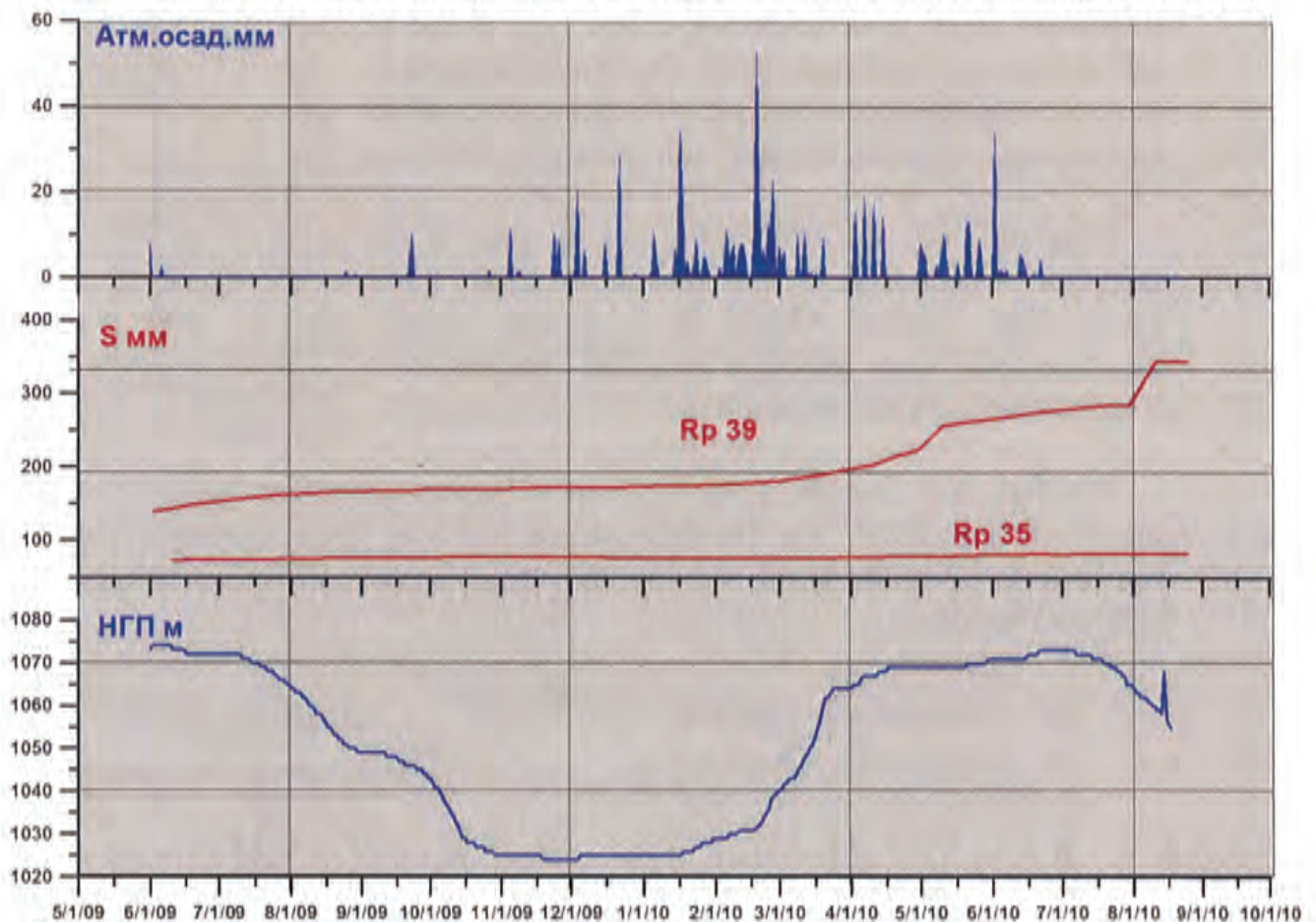
Thus, the Tanga-Topdi impression type landslide during 30 years is in active condition. Its dynamic, probably related to cycle

of inflow and discharge of water in water reservoir. The hazard of the landslide is in formation of new cracks above the existing landslide scarp on the highway roadbed.

To understand the factors on 06 of March 2009 three Extensometers were installed and three boreholes were drilled for Inclinator observations.

#### Extensometer results.

The measurements for 15 month (from 3 of June 2009 to 25 of August 2010) showed that Extensometer 39 installed in the upper zone, on the upper crack fixed 204 mm of soil movement. On correlation of data received with amount of



Graph of precipitation changes, soil movement value and water level fluctuation in water reservoir

precipitation and water level fluctuation in the water reservoir, clearly shows that landslide movement speed increasing when level of water in water reservoir reached 1070 elevation and it's in above the flood-plain condition. Landslide movement speed was not increased in spring 2010 when water level in water reservoir was in low elevations. It is a very important indicator.

Second Extensometer 35 locates in the middle zone of landslide area, where insignificant displacements were fixed, in spring time inside the landslide. This Extensometer will be remained in order to understand whether local generations is forming on the landslide or not, whether it's related to the main displacement or not.

The third Extensometer was installed in the low part at the protrusion wall and no movements fixed. In this regard it was removed to the other landslide.

### Inclinometer results.

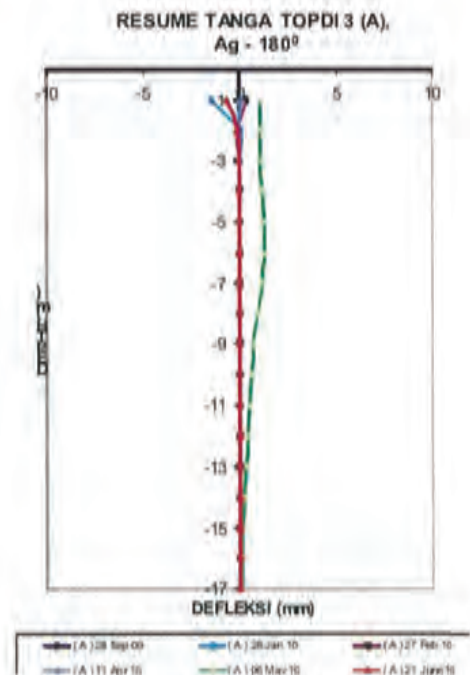
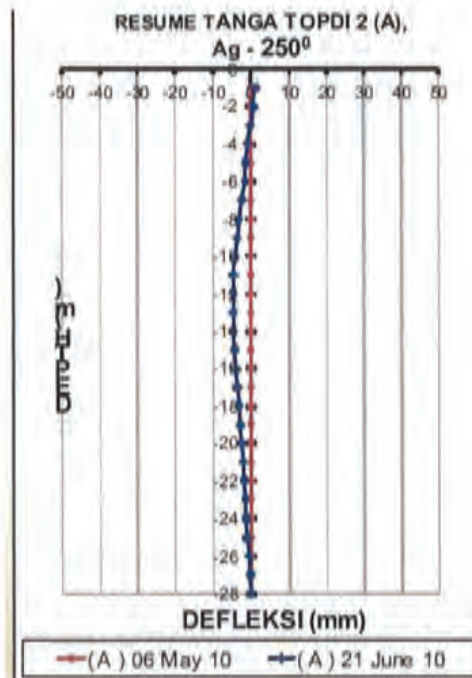
The electric sounding works were implemented at the site. Field investigations carried out by electric sounding machine McOHM-EL, made by OYO Japanese Company.

Based on geo-resistivity the geologic-geophysic cross section was prepared.

Borehole №1. Locates in the upper part of the landslide (upper than landslide scarp). The borehole was drilled on 09 of June 2010. The borehole depth is 4 m, 6 cycle measurements were implemented. Based on last measurements insignificant change is observed.

Borehole №2. Locates in the central part of the landslide. The borehole was drilled on 23 of April 2010. The borehole depth is 28,5 m, 2 cycle measurements were implemented. The changes from 4 m to 26 m in depth are observed.

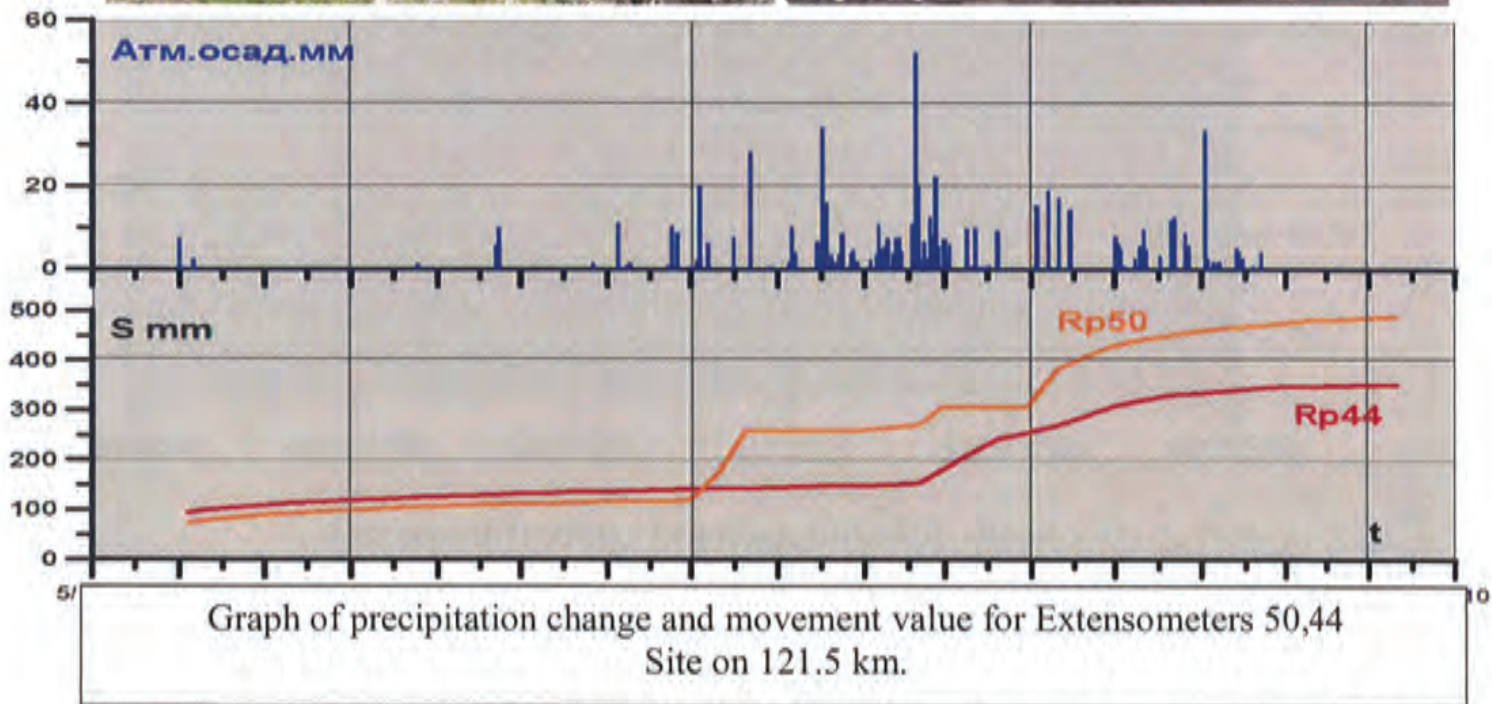
Borehole №3. Locates in the low part of the landslide. The borehole was drilled on 09 of June 2010. The borehole depth is 17 m, 6 cycle measurements were implemented. On the graph the changes are observed in May, in other cycles no changes observed.



**Chetsu Landslide (121.5 km of Tashkent – Osh highway)**, formed in 1995 as a result of slope cutting and slope watering by ground water. Initial volume of the landslide was 150t.m3. In the process of road expansion deep slope, the landslide

slope has been collapsed. Meanwhile, upper blocks settled deeper and new cracks appeared uphill. At present time, the crack elongated up to 90 – 100 m, with altitude up to 0,5 – 0,7 m, remaining landslide volume is 25,0 t. m<sup>3</sup>. To control the cracks expansion, considering hazard for Tashkent – Osh highway, on 04 of June 2009 two Extensometers 44,50 were installed. Extensometer results for 14 month showed that total movement for Ext. 44 is 257 mm, for Ext. 50 is 415 mm. The biggest movements occurred in spring period from February to April 2010. Movement graph is characterized by stepwise soil movement.

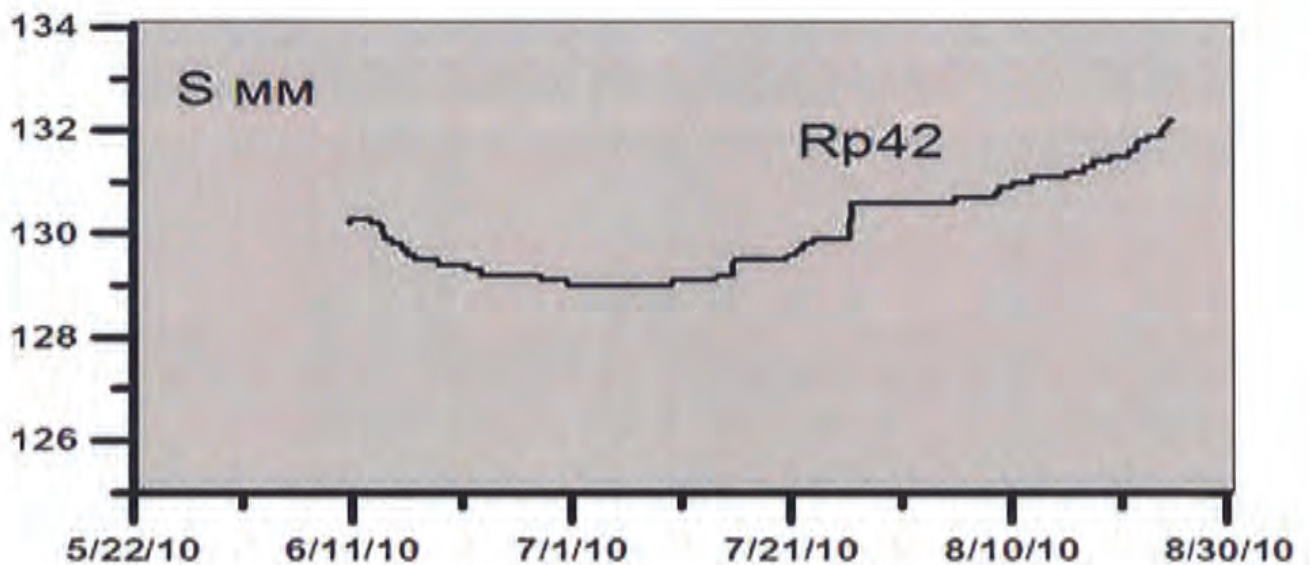
The biggest displacements related to rainfalls on 19 of February 2010 – 52,4 mm, 12 of April – 35 mm with intensity up to 30 mm/hour. The observations by Extensometers will be continued in the future, at the landslide site.



**Humsan Landslide in Humsan village**, was formed in the beginning of March 2010, at the slope of 200 m in height and steepness 20 – 30 gradient. In 1996 the loose crack was activated of 150 m in length, as a shape of graben of 8 – 12 m in width and strongly fractured cracks up to 2 – 3 m in deep, with altitude up to 1,5 m.

Expected volume of the landslide is 40,0 t. m<sup>3</sup>, which can move toward steep gully directly to the settlements with unexpected after effects.

At present time, there are 5 houses in landslide hazard. To control development of the crack the ground type Extensometer 42, was install at the site on 10 of June, 2010. For 75 day observations the displacements were just 2 – 3 mm, and it also has stepwise movement. In the future it is planned to install long span Extensometer through graben dips, on its terraces.



Graph of soil displacement in time (Humsan site)

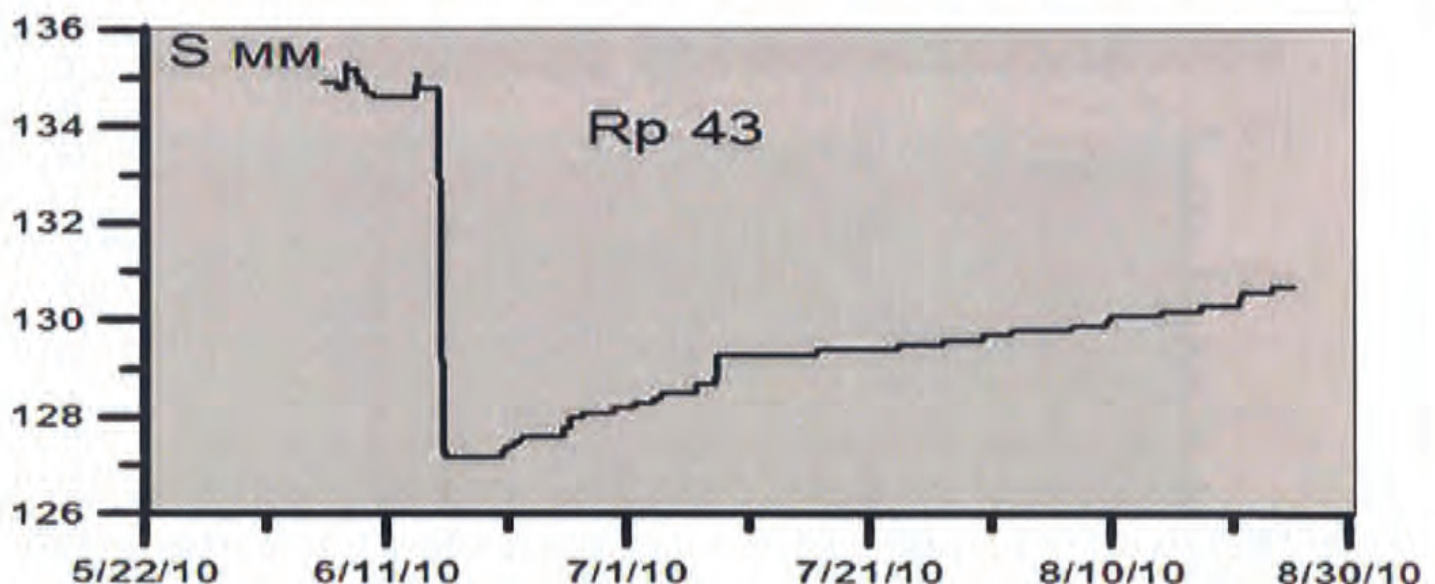
**Semgran Ladside** – landslide crack above the stulm 90 of Kochbulak minefield. In 2003 in 70 m above the stulm the crack of 260 m extension, 0,1 – 0,4 m width and 0,8 m altitude was formed.



In 2008 above the stulm in the extension of 180 – 200 m, width 0,3 m and altitude 0,5 m on 20 of April in the site two new cracks were fixed in loess soil, one in the lower part of 80 m extension, the other on 20 m higher on the watershed surface, with 60 m in length, 0,1 – 0,2 m in width, 0,3 m altitude.

In order to determine cracks development dynamic, at the section formed in 2003 above the saw bench, on 5 of June 2010, the Extensometer 43 was installed.

First observation results for three months in summer time showed insignificant cracks expansion 5 – 9 mm. Theses have stepwise movement. In the future it is planned to continue Extensometer observations at the site.



Graph of soil displacement on the Semgran landslide crack.

**Substation Landslide 112 km of highway** covers area from Tashkent – Osh highway to Centralny Landslide. First deformations as cracks appeared in 1993 in 35 – 40 m from highway. Series of cracks length of 100 – 500 m covered upper terrace on 700x300 m area, breaking the below terrace. Main reason of

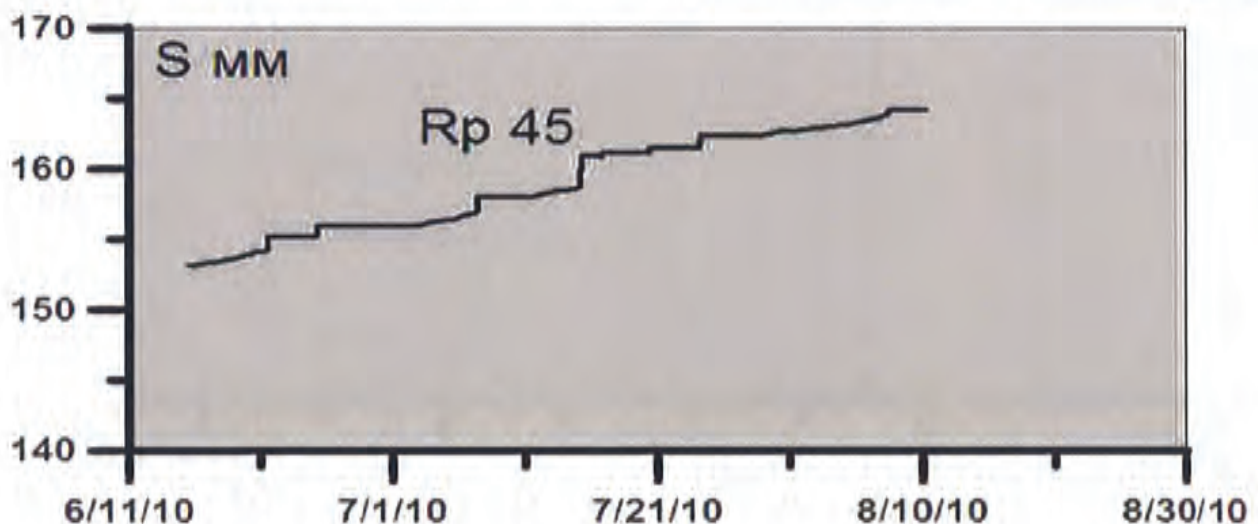
deformations was continued watering of overburden by underflows. From 2001 connection process of Substation landslide with head scarp of Centralny landslide cracks of has been started.

In 2003-2004 upper terrace removal was implemented as a result terrace deformation strongly reduced. However, in 2008-2010 the terrace deformations appeared again in the upper zone and in the lift side, which greatly complicated the current state of working side.

To determine movement mechanism on the left flank of the crack on 15 of June 2010 the Extensometer 45 was installed.

Measurement results from 15.06 to 10.08 showed insignificant soil movement – 11 mm in summer time.

At present, the extensometer destroyed, but work to control the soil movement will continued as it is very important and complex object of observation.



Graph of soil displacement in time for Substation landslide.

### Conclusions:

- Precision automatic measurements of soil movement by Extensometers allow determining the exact time of the beginning of soil movement, bursts time, the duration and total amount of soil movement, the changes nature of absolute value of soils velocity in time.

- This set of continuous high-precision observations can determine the timing and nature of impact from precipitation, seismic, vibration and other man-made factors on activation of landslide processes.

- To increase the reliability of warning information on the basis of studying the landslide mechanism in time.

Future works for 2010-2012:

1. At present time, for the scope of work for Bostanlik and Angren MS for 2010 – 2012 drilling of 8 boreholes (total volume is 370 m) is planned.

For Bostanlik MS :	Tekstilshik landslide – 1 borehole.-50 m,
	1 borehole - 60 m.
	Mingchukur landslide – 1 borehole 40 m.
	1 borehole -50 m.
For Angren MS :	Pustinlik landslide – 1 borehole - 50 m.
	Verhne-Turksky landside – 1 borehole - 40 m.
	1 borehole.-40 m.
	Djiblan landslide – 1 borehole -40 m.

2. For all boreholes systematic Inclinator observations will be conducted to identify the location of the landslide slip surface.

3. At the 8 landslide areas is planned to continue measurements using 12 Extensometer, for 5 sites will be installed 6 new extensometers (see table). Depending on the landslide movement dynamics the areas for installation of Extensometers may be changed.

Landslide areas where the observations are made, and new Extensometers will be installed

	Sites	Existing Extensometers	New sites for Extensometers indstallation
1	Tekstilshik	3	-
2	Uchterek	1	-
3	Mingchukur	2	1
4	Humsan	1	-
5	Beshkaragach	-	1
6	Pustinlik	-	1
7	Tanga-Topdi (120km)	1	-
8	Chetsu (121.5km)	2	-
9	Semgran	1	-
10	Verhne-Turksky	-	1
11	Djiblan	-	1
12	Bedrenget	1	-
13	Substation	-	1
	Total	12	6

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