ER-TRG01 Regulation for Trial Sections – Inspection System

For the comparison and evaluation of the accuracy of different compactness test methods

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1.) Introduction, antecedent

On the basis of the Regulation of National Speedway Co on the procedure and test order of the measurements of compactness on the experimental or trial section ANDREAS Ltd worked out an inspection system, which determines the reliability and accuracy of the measurement methods needed for the inspection of the extremely high compactness requirements with large number of samples and parallel tests; it evaluates and compares the results for application of he speedway constructions.

This inspection system is the intellectual property of the "Engineer", which regulates the preparation, number and execution method of the measurements, its rules, the evaluation of results and its circumstances and the method of determination of the required statistical reliability.

2.) Elements of the inspection system, requirements

The elements and parts of the inspection system are as follows: preparation of inspections, qualification tests, trial compactions, measurements and evaluation.

Trial compaction must be carried out for all material types and all layers separately simultaneously with trial in-building, by which maximum 50.000m^2 surface in case of earthworks 25.000m^3 can be typified differently from the tender.

The inspection system used the general directives worked out by ANDREAS Ltd for the regulation of trial in-buildings and trial compactions.

2.1.) Preparation of inspections, conditions

The inspections can be carried out only with calibrated or tested measuring gauges and by personnel having experience (i.e. Institute for Transport Sciences) skill examination trained in the course.

Before measurement the site and laboratory inspection equipments must be checked carefully regarding calibration, operability and accuracy. For this the heads of the laboratory are responsible.

At the first commencement of the works the laboratory charged by the Contractor and the Control Inspection Laboratory must carry out a comparative inspection for the equipments to be used in the planned measurements, but at least once a year and the equipments must be checked on the basis of the own regulation of the laboratories (calibration, charging level, own tests).

The inspections must be carried out on the basis of the valid European Standard or Road Technical Directive, except the Proctor-inspection, which must be carried out with increased Proctor number detailed in this regulation.

The partial results and reports of the inspections must be checked by the laboratories as per the own internal order of the laboratories before publication. The doubtful and/or uncertain data must be indicated in an eye-catching way and they must be eliminated in the evaluation.

In the inspection of the Client's and the control laboratory (represent the customer) the data of the approved qualification test must be used as *reference density* until the results of the site sampling are not available. The results of the Proctor test of the sample taken during the trial compaction cannot be contracted with the results of the preliminary qualification test,

except if the difference of the gravel – sand – gravel composition features determined from the grain-size distribution is smaller than 10 % and the difference of the silt – clay composition features is smaller than 5 %.
The laboratories shall issue and send the inspection reports for evaluation on the basis of this latter. The measurement data of the independent control laboratory will be used to represent the reproducibility and they increase the number of the inspection results in the evaluation of the Engineer.

The Contractor Consortium prepares the site of the inspections – in accordance with the rules of trial compaction – in a shape and size as indicated in this regulation. The Contractor must provide the compacting device needed for compaction as indicated in the Enclosure attached hereto. All applied machine types (sprinkling trucks and grader being suitable for the spreading, etc.) must be the as planned to be used during construction.

2.2.) Number of inspections required minimally

The inspections must be carried out in a number prescribed in this regulation, as necessary for the statistical evaluation and the required reliability, parallel inspections and the determination of deviation. The measurement data of the independent quality control can be evaluated independently, only if the number of measurements reaches the minimally required and prescribed number. Otherwise, if the identity of the expected value is accepted, it increases the inspection aggregate without group separation.

2.3.) Evaluation of the measurement results

After executing the inspections in a number prescribed in this regulation the measurement reports and the partial results must be handed over to the Engineer that will executes the statistical evaluation and calculates the reliability interval and prepares the evaluation summary table for the NS Co. The circumstances the measurement results must be recorded on the basis of the rules of trial compaction.

The evaluation covers the determination of the measurements' deviation, reproducibility and reliability interval and the acceptability of the identity of the expected value. In case of an individual difference being higher than permitted, the reason of the difference must be analysed by individual inspection, which must be completed with the statistical and tendency inspection of E_{2v}/E_{1v} and compaction deformation curves. Regarding the difference its reason and most acceptable explanation must be presumed.

2.4.) Appointment of the measurement locations

The preparation of the location of the inspections – in accordance with the rules of trial compaction – must be executed by the Contractor Consortium. ***Generally,*** during the preparation and formation of the trial compaction the provisions of ÚT 2-3.101:1992:M2 enclosure must be followed in Hungary (see the enclosure). The aim of the trial compaction is to safely determine the compacting devices, number of runs, spreading thickness and the construction water content limits being suitable for the in-building of the given material (soil) and the deviation, expected value and reliability of the compactness inspections.

3.) Laboratory identification, qualification tests

Preliminary, the necessary qualification and identification inspections must be carried out on the sub-soil and planned material of the trial in-building as required by Sampling and Qualifying Plan (SQP); and the soil characteristics must be determined on the basis of these data. Typically these are the following: natural water content, grain-size distribution and elutriation, void-less density, loose bulk density, natural water content, floating limit, liquid

limit, minimum and minimum 2 pcs of 5-point Proctor series on *three homogenized squared samples taken from different locations* and organic-material content inspection.
In addition, in case of materials of natural fragmentation (crushed dolomite/limestone) as the part of the qualification test the water absorption and break-up habit of the part under <0,1 mm must be carried out also with Proctor machine; and the inspection of the decay habit with boiling test. In case of a water absorption higher than w = 3 % test of anti-freezing properties also can be done.

In case of quartz crystals neither the testing of anti-freezing properties, not the decay inspection must be carried out owing to he low water absorption.
Parameters to be determined and calculated:
Soil properties: Gr-Sa-Si-Cl, d_{60}, d_{10}, U, Ip, Ic, w_L, w_p, w_t,
ρ_s, S_r, $S_{0,8}$, $S_{0,9}$, $S_{1,0}$, ρ_{dmax}, w_{opt}, T_{rw}, I_{om},
plus (in case of crushed gravels): under break-up <0,1mm, decay, water absorption, anti-freezing properties.

These qualification tests must be carried out preliminary on the material of the layer planned to be in-built; and if they are acceptable, they must be introduced to the Engineer for approval before appointing the date of the trial compaction.
The ρ_{dmax} and w_{opt} value of the Proctor tests – besides the conventional 5-point evaluation – must be determined from the summarized data also (in accordance with the rules of statistical analysis maximum three Proctor points can be eliminated from the extreme values in comparison with the Proctor curve (max-min)). From the lumped Proctor-points both T_{rw}, and the reference density's ρ_{dmax} and w_{opt} values must be determined.

4.) Location of compaction

Te location of the trial compaction must be selected in a way that it represents the expected in-building circumstances; at the same time, it should be well-accessible and provide enough free space for the safe installation of the laboratory equipments, vehicles and the personnel and for the execution of the works. The participant of the trial compaction must observe the general safety and protective regulations of construction.

The location must be suitably dewatered and of homogenous surface. The trial compaction section must be marked to form a width of three compacting rollers and a length of minimum 15-20 m and one spreading thickness. The material–layer thickness of the planned trial compaction can be selected between 20–30 cm, but it must be of even thickness on the whole length. The length of the trial section must be marked in a way that it is suitable for the necessary measurements in three inspected cross-sections with a space of 3-5 m between them.

Preparation of sub-soil (earthwork surface, receiving surface):
The surface of the sub-soil (earthwork surface, receiving surface) must be smooth, fresh-cut, suitably compacted and must have suitable draining. The sub-soil must be compacted as the part of the preparation.

4.1. Control measurements and inspections needed on the receiving surface

On the compacted sub-soil at 3-5 m from the ends of the marked section and transversally between them *three inspected cross-sections* must be appointed and marked at their edges to make us be able to identify the given section after covering the receiving surface also. The measurement must be carried out in the same cross-section on the receiving surface and the compacted layer.

After then, the following required inspections must be carried out in each cross-section of a width of minimum three compacting rollers in a band of a length under 1,0m smoothly distributed in its whole width per laboratory:

- static load bearing capacity measurement: 2 pcs/measurement section (E_1, E_2, T_t)
- isotopic compactness measurement 3 pcs/section (ρ_n, w_t, $T_{r\rho}$%)
- determination of water content or sampling at the location of the measurement at all measurement points with laboratory back-drying with and site calibrated moister measuring gauge: 3 pcs/section
- dynamic compactness- and load bearing capacity measurement 3 pcs authoritative (i.e. 3 * 2 = 6 pcs)/section.
  observing E_{dM}, E_{dendM}, T_{rEM}%, T_{rw} and T_{rdM}%

If the water content must be measured at site with calibrated moister measuring gauge, then T_{rw} value must be set to the dynamic compactness measurement. Subsequently, when preparing the report a more accurate water content measured in the laboratory must be observed.

All times, when finishing the measurements sample must be taken to carry out minimum two series of Proctor inspections and water content inspection.

Documenting the measurements:

After then the measured inspection results must be averaged per measurement section, and then lumped for the whole section. Aggregately minimum 3 inspected cross-sections must be measured for the whole length of the trial in-building, which can be enlarged with a plus cross-section, if failure or large deviation (difference) is detected, as per the Engineer's decision.

When calculating, preparing and evaluating the measurement reports always the real (back-dried) laboratory water content and the Proctor properties determined with the 2*5-point method (ρ_{dmax}, w_{opt}, T_{rw}) must be considered both at isotopic both the dynamic compactness measurement.

4.2.) Site measurements of the examined surface

The trial compaction can be commenced, if the above-mentioned measurement results of the sub-soil meets the prevailing prescriptions apiece and averagely also.

The first loose spreading thickness – depending on the material – must be selected between 20-30cm compacted thickness; and then multiplied with the loosening factor (ρ_{dmax}/loose bulk density) the thickness to be spread must be determined. The spreading must be carried out with dozer excavator and/or grader (but with the same machine and in the same way as applied during construction) smoothly; and it must be compacted with a roller and number of runs selected from this enclosure. The proposed roller types of the individual soil types are included in this enclosure.

The possible dampening must be carried out with sprinkler truck spread smoothly after the first planishing; and after it has soaked in, the planned compacting must be continued. Before the last roller run of the compacting the surface must be cut even and closed with a smoothing roller.

During a trial compaction a repeated dynamic compactness measurement must be carried out both on the sub-soil and the material layer at the first dynamic compactness measurement in the same measurement track (without relocation) to check (verify) that the dynamic work executed on the layer as reached the planned Proctor compaction. (Its first measurement can be evaluated as one of the parallel inspections). The relative dynamic compactness degree of

the second measurement repeated at the same location - without moving the plate - must exceed T_{rE}%=98% (and in case of the third measurement the T_{rE}%=99%).

4.2.1. Measurement and inspection method

Before measurements the material of trial compaction, the compacting method, number of runs and its circumstances must be recorded exactly. After then the followings must be measured in all three inspected cross-sections in the same number per cross-section:

- bulk density, water content with isotopic measurement (ρ_n, w_t, $T_{r\rho}$%) 3 pcs/section
- water content with laboratory back-drying and T-90 water content measuring gauge with an accuracy of 1 % 3 pcs/inspected cross-section
- dynamic compactness- and load bearing capacity (E_d, E_{dend}, T_{rE}%, T_{rw} and T_{rd}%) 3 pcs/section
- static load bearing capacity (E_{v1}, E_{v2}, E_{v1}/E_{v2},) 2pcs
- Further inspections prescribed by Engineer, e.g. determination of bulk density with sand filling method or sampling cylinder and/or site Proctor-inspection.

During measurement from the dynamic compactness measurement's T_{rE}% value the efficiency of the rolling work must be determined. If it did not reach the 97-98 %, then the compactness degree must be increase with further rolling or y changing the rolling method or type.

Executing the measurement in all three measurement sections (in the necessary number) the homogeneity of the results of the section and the layer must be determined (average, standard deviation, minimum and maximum value).

The thickness of the spread compacted layer must be cut off after the measurements per cross-section at one location manually; and measuring the layer thickness in 4 direction with an accuracy of ± 1cm and averaging the layer thickness of the given cross-section must be determined.

As per the decision of the Engineer the layer's measurements can be accepted pr in case of large differences they can be completed. If further measurement is necessary, then extra measurements must be carried out on the unchanged layer in a plus cross-section.

When finishing the measurements sample must be taken for the execution of minimum two series Proctor inspections and water content inspections.

For the parallel dynamic compactness- and load bearing capacity measurements the tolerance limits included in CWA 15846 (ÚT2-2.124) are valid. For the acceptable tolerances of the parallel execution of the static load bearing capacity measurement included in its Standard (MSZ 2509-3 in Hungary) and the isotopic compactness measurement there is not requirement included; therefore if the *difference from the average* is higher than ± 20 %, it is expedient to increase the number of measurements. The Engineer decides it at site during the trial compaction.

If the difference of the average of the isotopic compactness degree measured at the same point and the average of the dynamic compactness measurement is considerable (>6Trg%), then the reason of the difference must be analysed and identified at site. For this the difference of three partial results of the wet density and the identification of the measured water content and the real water contents (determined with laboratory back-drying) must be checked; and the presumable compactness statues must be determined from E2v/E1v value

and the curve of the dynamic compactness measurement(s) executed at the same location also (these data can be printed out at site). If the T_{rw} moisture correction factor is known, T_{rE}iz% relative value must be checked and calculated from the isotopic compactness degree, which typifies the efficiency of rolling and if its value is above 100 %, it is able to explore the possible gross errors of the isotopic measurement also.

4.2.2. Plus layers, changing of layer thickness and compacting method

If the compacting method is changed the layer must be compacted by a rolling of different type in accordance with a technology chosen at site, including or excluding dampening.

The volume of the water sprinkled for dampening must be measured by the help of a tray or vessel. The post-dampening water content must be determined by quartering and measuring the sample taken from the whole layer thickness.

After finishing the rolling the measurements included in the previous chapter must be carried out. The measurement results must be well identifiable and confusion must be eliminated. It is expedient to attach a draft about the site of the measurements to the trial compaction documentation.

The layer thickness can be changed by forming a section of similar dimensions as the trial compaction section beside the original one, by enlargement or the complete removal and rebuilding of the built layer. In both cases the repetition of the sub-soil inspections is necessary.

4.2.3. Control measurements:

Te test points of the independent (Customer) laboratory appointed for measurement are determined by the Engineer. The measurement results serve for complete and compare the date of the trial compaction and for checking the reproducibility; and they can be indicated in the documentation accordingly. The Engineer is entitled to inform himself/herself and charge further laboratories with parallel inspections or to use own (similarly calibrated) measuring gauge.

During the determination of the isotopic compactness degree, if the T_{rw} moisture correction coefficient is known, the T_{rE}iz% value always must be checked and calculated also, which typifies the efficiency of rolling; and if its value is above 100 %, it explores the measurement error also.

4.3. Interruption of trial compaction, delayed measurements

If the trial compaction must be interrupted for any reason, but further measurements should be executed on the surface, then the Engineer is entitled to pronounce the trial compaction as incomplete. In this case the whole surface must be covered with a PVC foil overlapped in slope direction, charged, covered with laths and weighted. The area must be bordered from machines. On the surface conserved in this way after one or two weeks the measurements can be repeated or continued.

5. Evaluation of measurements

The evaluation of trial compaction is combined by the Engineer on the basis of the trial compaction documentation and the qualification test and independent and control measurement results provided by the Contractor.

The evaluation must include the identification data of the laboratories and measurements per measurement type and the main statistical properties, such as average, standard deviation, relative deviation, minimum, maximum, number of samples, Student-factor at α=0,1 significance level and the range of expected value. The analysis and evaluation must include minimum the following properties:

- Isotopic compactness degree – dynamic compactness degree
- Relative compactness degree of isotopic compactness and dynamic relative compactness degree
- Isotopic water content – laboratory water content – water content measured with gauge

The main consequence of the evaluation is the acceptance or rejection of the identity of the expected values, which must be determined and calculated besides indicating the applied significance level and number of samples. Generally, the Proctor properties (ρ_{dmax}, w_{opt}, T_{rw}) must be used for comparison, which are less charged with errors and are determined with larger number of samples

If the difference of the average of the isotopic compactness degree measured at the same point and the average of the dynamic compactness measurement is considerable (>6Trg%), then the reason of the difference must be analysed and identified at site. For this the difference of three partial results of the wet density and the identification of the measured water content and the real water contents (determined laboratory back-drying) must be checked; and the presumable compactness statues must be determined from Tt value and the curve of the dynamic compactness measurement(s) executed at the same location also (these data can be printed out at site also). If the T_{rw} moisture correction coefficient is known, T_{rE}iz% value must be checked and calculated from the relative isotopic compactness degree, which typifies the efficiency of rolling and if its value is above 100 %, it is able to explore the possible gross errors of the isotopic measurement also.

One trial compaction can be related for the in-building of maximum 50.000m^2 area or 25.000m^3 earthwork. The evaluation and summary of the trial in-building is prepared by the Engineer in the form of monthly quality control and it is submitted to the Client NS Co in the form of a report.

5.1. Content requirements of the trial compaction documentation

One set of documentation can be prepared for one material type; they cannot be contracted. All documentations include the evaluation of the qualification tests and site measurements of the sub-soil (earthwork surface or receiving surface), even if they are the same. One set of documentation must be prepared and evaluated in every month.

The summary table of the trial compaction documentation must include the main identification data, the considerable inspection results and their statistical properties (average, deviation, minimum, maximum, number of samples) and in a separate appendix the inspections reports of the sub-soil and material layer, on the basis of which the tables of the documentation are filled out.

The documentation must evaluate the trial in-building and its experiences; and finally, make proposal for the chosen material used for construction, which fulfils the prescribed limit values and the spreading loose and compacted layer thickness, the compacting technological data, such as the type of applicable compacting rollers, number of runs and in-building water content limits. For the calculation of the compactness degree, which is based in the density rate, when determining the bulk density minimum 2x5 = 10 Proctor points (maximum 2 virtual points) must be observed for ρ_{dmax} and w_{opt} and T_{rw} values.

The documentation must include the material-typical tolerance limits observed during procedural control and the permitted interval of ρ_{dmax}, whose non-fulfilment requires the execution of a new trial compaction.

On the basis of the experiences of the trial in-building and the evaluation of the trial compaction documentation and the summarized evaluation the Engineer decides about the type of the further control and qualification compactness measurement, for which the Contractor must make proposal, if the requirements in the Tender are met. The qualification inspection of the maximum 50.000 m^2 (or 25.000m^3 earthwork) surface prepared in this way must be carried out at a frequency determined in SQP; and the results must be summarized in the qualification documentation (QD).

6.) List of applicable standards and prescriptions

List of relevant standards in the country.

7.) Enclosures

LABORATORY 1.

TRIAL COMPACTION SITE SUMMARY

PLACE / ROAD N°

Trial compaction location: …….. + … km - …….+ … km/ID: **Date** 2015-..-..

1.trial compaction section: …. + …km ☐

2.trial compaction section: …. + …km ☐

3.trial compaction section: …. + …km ☐

SUB-SOIL

QUALIFICATION TEST RESULTS

Soil properties:

Gr: Sa: Si: Cl: d_{60}: d_{10}: U: Ip: Ic: wt: w_L: w_p: ρ_s: S_r: $S_{0,8}$: $S_{0,9}$: $S_{1,0}$:I_{om} attached

ρ_{dmax}=____ w_{opt}= ____ T_{rw} table attached $\rho_{d\,95\%}$=____ $\rho_{d90\%}$=____ $\rho_{d85\%}$=____

SITE INSPECTION RESULTS

Roller run and method ____ r=rubber-wheel / v=vibro/ s=static steel shell / o=other

Layer thickness: …. cm loose, measured compact cm: ____ ____ ____

T-90	Static load bearing capacity	BC	Isotopic compactness measurement	CWA dynamic compactness measurement										
wt	E_1	E_2	E_2/E_1	Ed	Nº	wiz	ρn	ρsz	Trρ%	Trw	TrE%	Trd%	Trd%	Type
					1									1/1
					2									>98
					3									>99
														1/2
														2/1
														2/2
														3/1
														3/2
														../3
														../3

Other measurements: sampling cylinder ☐ , sand spreading ☐ , site Proctor ☐

Volume of sprinkling: ____ ____ ____

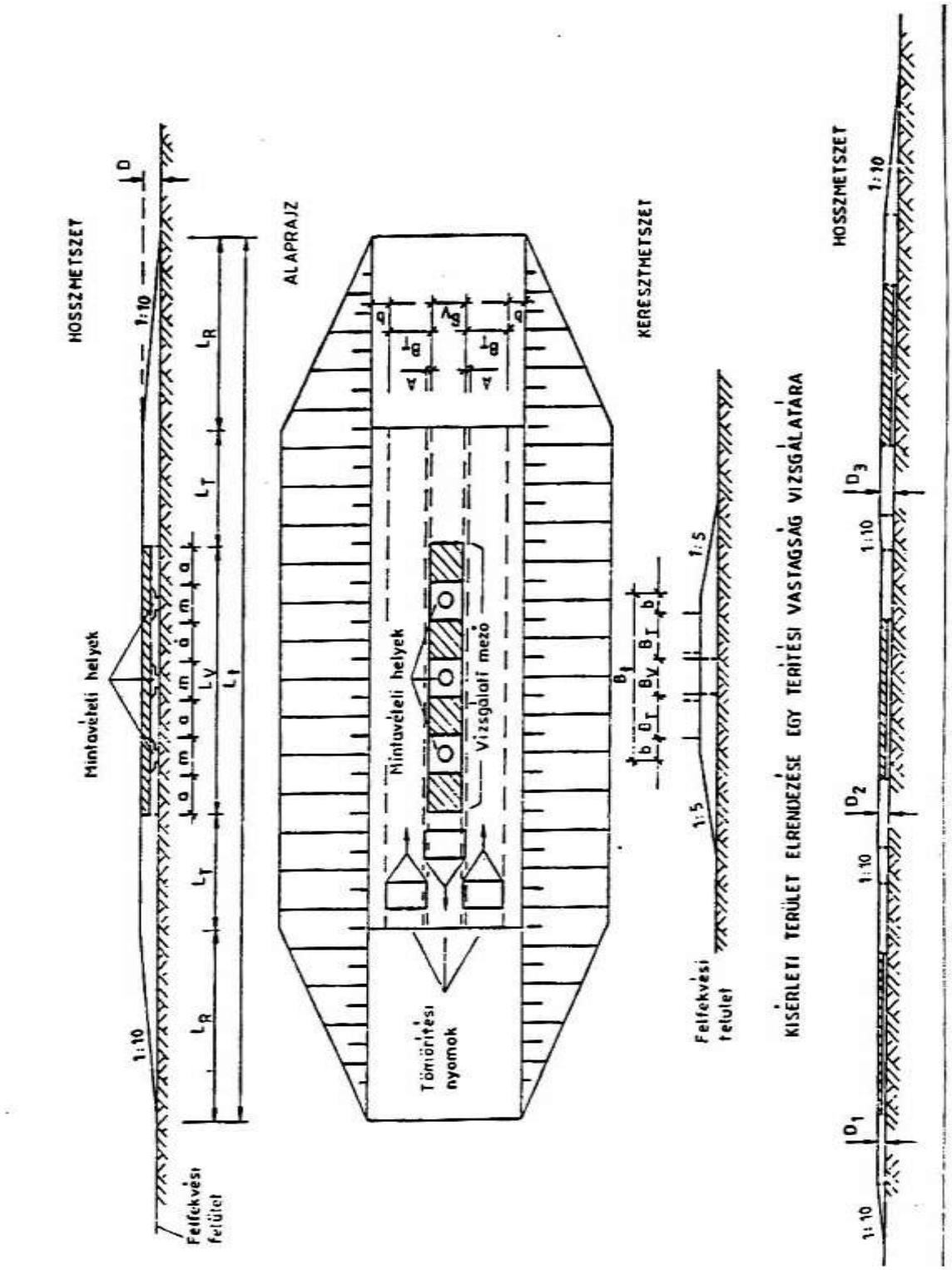
Comments, draft of the locations of measurement:

MELLÉKLET
(Tájékoztatás)

7. táblázat

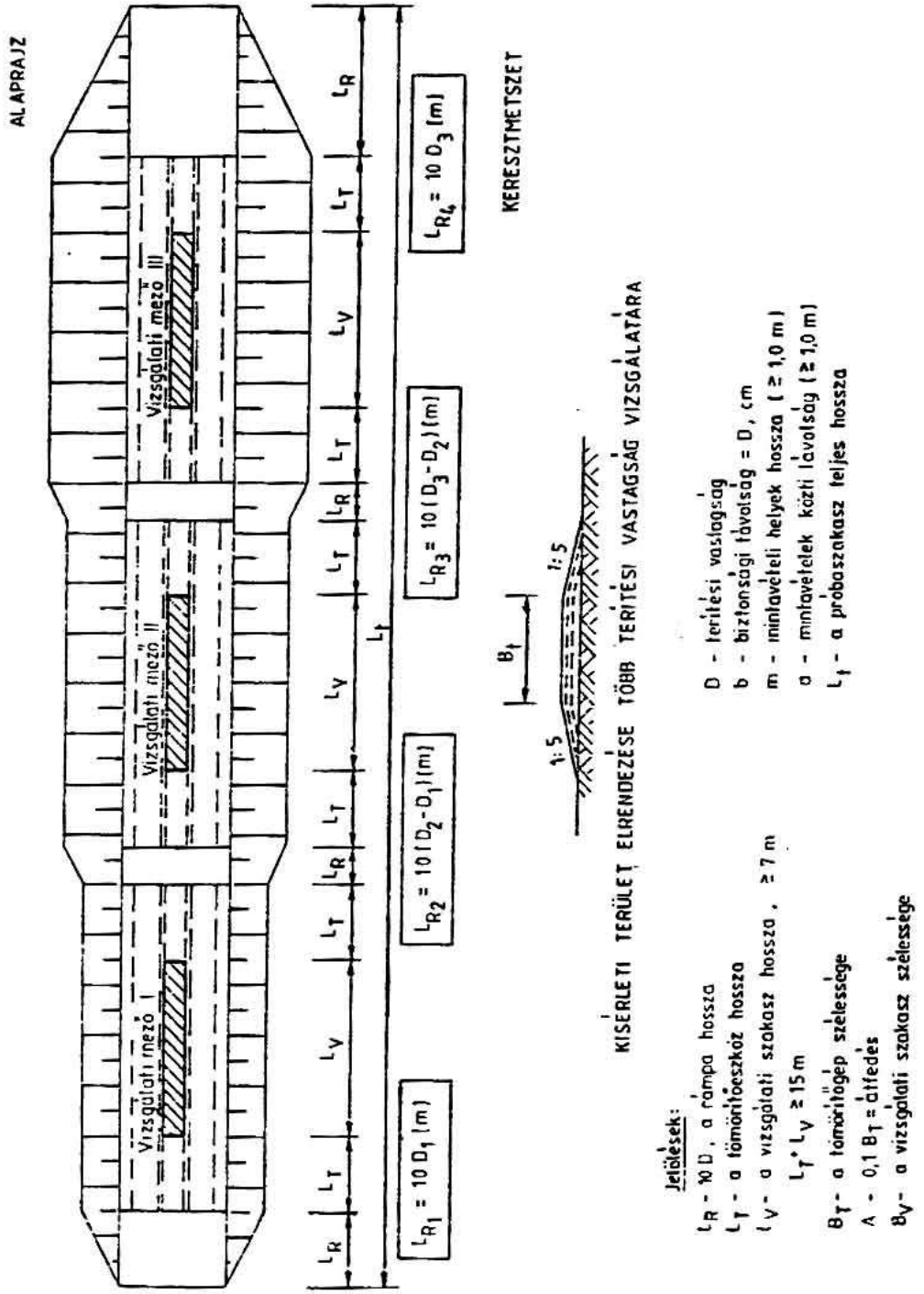
M.1 Talajok tömörítési osztályai

Talajok tömörítési osztályai				Tömörítési víztartalom tűrései		
A talaj				Az optimális víztartalom meghatározása az MSZ 14043/7 szerint		
oszt.		megnevezése	talajfizikai jellemzője	(–) Kisebb víztartalom	w_{opt}	(+) Nagyobb víztartalom
(J)	jól töm	Kavics, homok, kavicsos homok, homokos kavics homoklisztes homok	U ≥ 7			
		Agyagos kavics, agyagos homok, homokos agyagos (iszapos) kavics	Iszap + agyag < 20%			tűrése csak akkor alkalmazható, ha az emiatt csökkent
(K)	közepesen tömöríthető	Közepesen gradált szemcsés talajok	U = 3 - 7			
		Vegyes szemszerkezetű szemcsés- és kötött talajkeverékek (agyagos kavics, agyagos homok, stb)	Iszap + agyag = 20-30%			nyírószilárdság az állékonyságra nem hat.
		Iszapos homokliszt, homoklisztes iszap, iszap- és sovány agyagtalajok	Ip = 7 - 15%			
(N)	nehezen tömöríthető	Egyenletes szemeloszlású szemcsés talajok, rosszul gradált kavics, futóhomok, folyós homok	U < 3			
		Erősen kötött és szemcsés talajok keveréke	Iszap + agyag > 30%			
		Iszap és sovány agyagtalajok	Ip = 15 - 25%			
		kövér agyagtalajok	Ip ≥ 25%	-6 -5 -4 -3 -2 -1		1 2 3 4 5 6

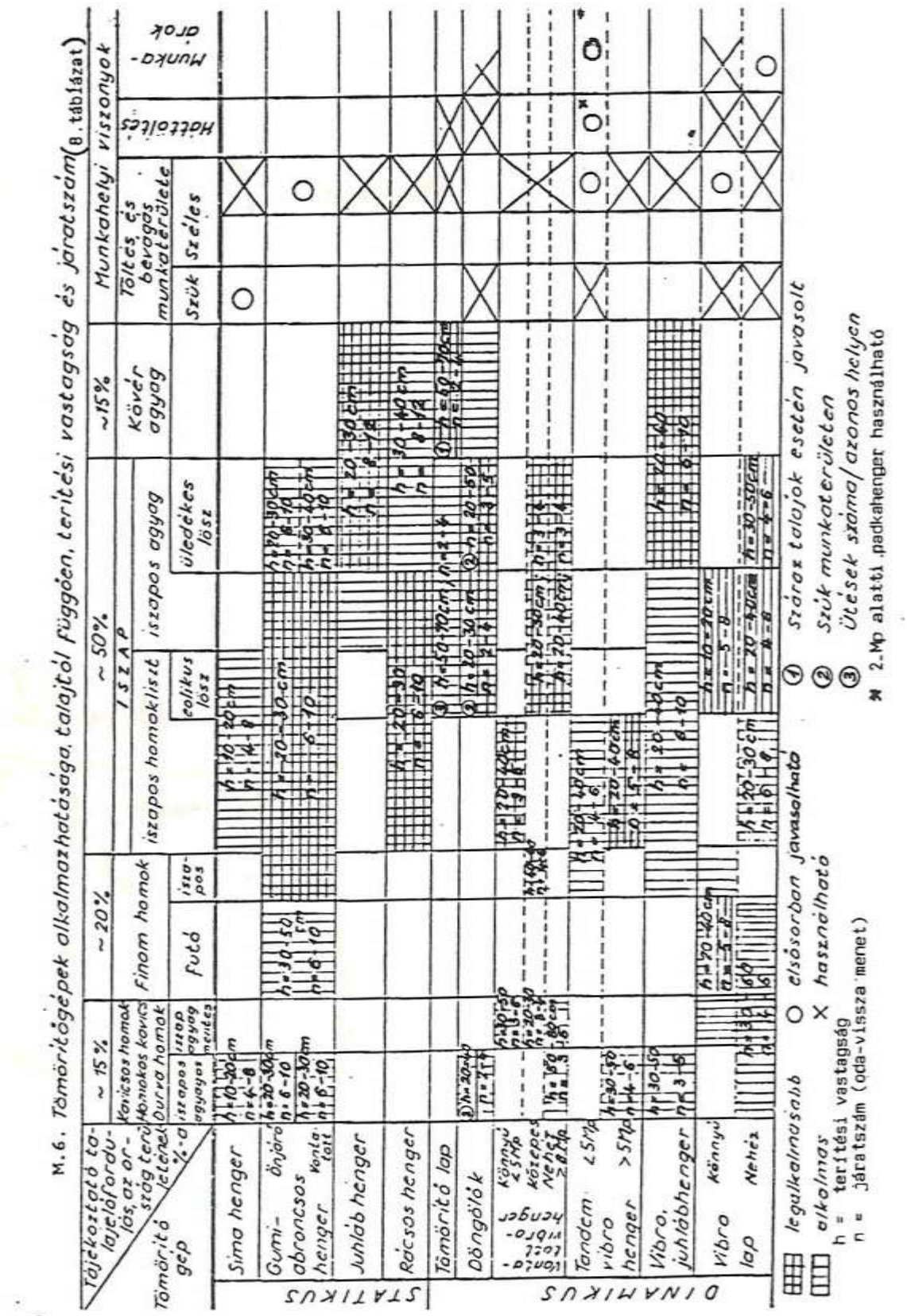


3. ábra

A jelmagyarázat a 4. ábrán található.


ALAPRAJZ
Vizsgálati mező I
Vizsgálati mező II
Vizsgálati mező III
$L_{R1} = 10\,D_1$ (m)
$L_{R2} = 10\,(D_2 - D_1)$ (m)
$L_{R3} = 10\,(D_3 - D_2)$ (m)
$L_{R4} = 10\,D_3$ (m)
L_R
L_T
L_V
L_t
KERESZTMETSZET
B_t
1:5
1:5
KÍSÉRLETI TERÜLET ELRENDEZÉSE TÖBB TERÍTÉSI VASTAGSÁG VIZSGÁLATÁRA
Jelölések:
L_R - 10 D, a rámpa hossza
L_T - a tömörítőeszköz hossza
L_V - a vizsgálati szakasz hossza, ≥ 7 m
$L_T + L_V \geq 15$ m
B_T - a tömörítőgép szélessége
A - 0,1 B_T = átfedés
B_V - a vizsgálati szakasz szélessége
D - terítési vastagság
b - biztonsági távolság = D, cm
m - mintavételi helyek hossza (≥ 1,0 m)
a - mintavételek közti távolság (≥ 1,0 m)
L_t - a próbaszakasz teljes hossza

4. ábra


M.6. Tömörítőgépek alkalmazhatósága, talajtól függően, terítési vastagság és járatszám (8. táblázat)
Tájékoztató talajelőfordulás, az ország területének %-a
Tömörítő gép
~ 15 %
~ 20 %
~ 50 %
~ 15 %
ISZAP
Munkahelyi viszonyok
Kavicsos homok
Homokos kavics
Durva homok
Finom homok
iszapos homokliszt
iszapos agyag
kötött agyag
fúvó
iszapos
celitkus lösz
üledékes lösz
kövér agyag
Töltés és bevágás munkaterülete
Szűk
Széles
Hőtöltés
Munkaárok
STATIKUS
DINAMIKUS
Sima henger
Gumi- önjáró abroncsos henger
vontatott
Juhláb henger
Rácsos henger
Támörítő lap
Döngölők
Könnyű <5 MPa
közepes 5-12 MPa
Nehéz >12 MPa
Tandem vibro henger
Vibro, juhlábhenger
Vibro lap
Könnyű
Nehéz
legalkalmasabb
alkalmas
h = terítési vastagság
n = járatszám (oda-vissza menet)
elsősorban javasolható
használható
① Száraz talajok esetén javasolt
② Szűk munkaterületen
③ Ütések száma/azonos helyen
* 2. Mp alatti padkahenger használható

8. táblázat