Deformation Measurements of the Most Important Structures in Slovak Nuclear Power Plants

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Key words: Deformation measurements, vertical displacements, nuclear power plants, monitoring, hydrostatic and pendametric measurements, prediction of deformations.

SUMMARY

Monitoring measurement methods of vertical displacement determination of the main operation block base in the nuclear power plant Jaslovské Bohunice. Knowledge and experience resulting from the measurements about 100 epochs, stages of measurements of main operation block. Exploitation of the hydrostatic and pendametric measurement systems of Institute of Measurement of Slovak Academy of Sciences for tild measurements of selected structures in Slovak nuclear power plants.

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1. INTRODUCTION

The construction of Jaslovské Bohunice nuclear power plant (NPP) V-1 started in 1973 with the Reactor Unit 1, which was connected to the national power network in 1978. After 4 month also the Reactor Unit 2 was put in operation. Afterwards the effort was connected on the construction of the second plant NPP V-2. Here a new reactor V-213 was used instead of NPP V1 old type V-230. Significant differences consist here in the way of nuclear power plant operation as well as in the safety system equipment. On 20.8.1984 the Unit 1 of NPP V-2 started the operation and one year later then Unit 2. The complete power output of both NPP is 1760 MW and cover approximately 45 % of power consumption in the Slovak Republic. Figure 1 presents location of power plants in Slovak Republic.

A team of engineering surveyors from the Department of Surveying has been substantially involved in long periodical systematic measurements of objects of both NPP (since 1973). The team headed till 1989 by O. Michalčák and since then by Š. Lukáč has realised about 100 measurement epochs of the main operation block (MOB).

The measurements were analysed mainly as a part of research projects of the Department of Surveying. Otherwise the Department co-operated closely with the Institute of Measurement of the Slovak Academy of Sciences (IM SAV), which developed new instrumentation installed at NPP Jaslovské Bohunice, namely hydrostatic and pendanetric systems for the tilt measurements of reactors.

2. CHARACTER AND EXTENT OF THE MONITORING

Generally the construction and operation of a NPP is very complicated and the irregular vertical displacements and complex deformation are of immense importancy for its operational reliability and safety. Additionally to that the NPP Bohunice was an experimental construction realised on special geological conditions with a new foundation concept with large size turbogenerators.

Therefore it was necessary to adapt and to develop the methods of measurement and monitoring and accordingly. Methodology of measurement for the NPP – V1 was designed by the team of our department and for the NPP – V2 in co-operation with Czech colleagues from the Energoprojekt Prague. Measurement and monitoring of deformation processes of the NPP - V1 and V2 consist of following particular tasks :

- Verification of the stability of vertical control points,

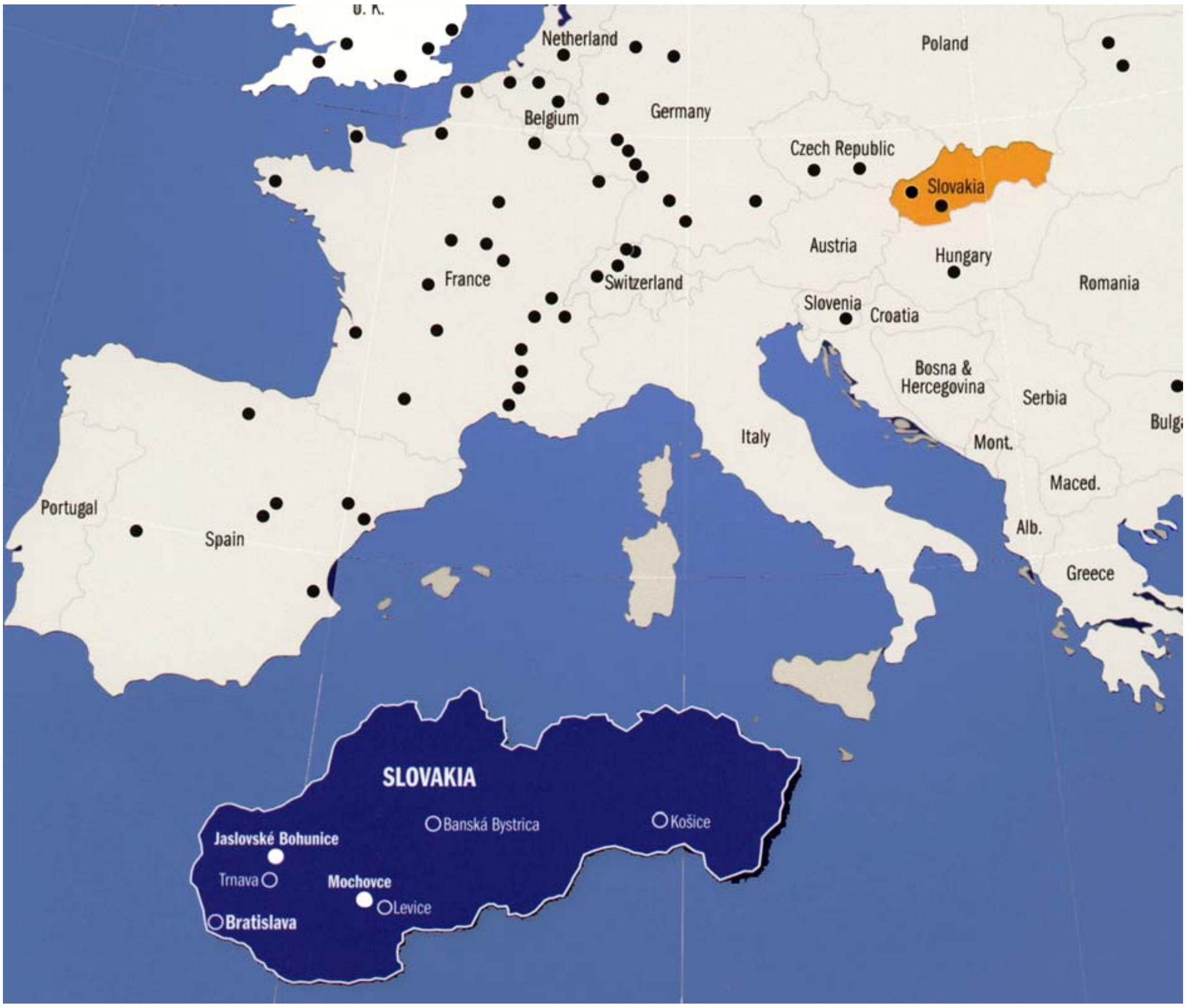

Figure 1 Location of the nuclear power plants in Europe and in Slovakia

- Measurement of vertical displacements of the MOB,
  - Tilts of reactors (by 3 independent methods),
  - Vertical H displacement of turbogenerators (in 3 horizons),
  - Vertical H displacement of steam generators and hydrocircular pumps,
  - Vertical H displacement of the MOB building,
- Measurement of vertical displacements of cooling towers,
- Measurement of the tilt of chimneys,
- Monitoring of the temperature at observed points (targets) and that of particular construction or structures,
- Monitoring of operational conditions (performance, rotations etc.),
- Monitoring of complementary factors (temperature and humidity of foundation soil, ground water level etc.).

For measurement of the tasks mentioned we use following methods :
- Precise levelling (using Wild N3 precise level),
- Hydrostatic leveling (Nivelomat PC),

- Tilt measurement by pendameters.

In all epochs we use the same methodology of measurement. The instruments stations are chosen according to the optimal plan of measurement, which was developed for every particular object independently. Measurement of vertical displacement of turbogenerators is realisied in 3 levels, which are presented on figure 2. On the same figure you can also see cross section MOB of the plant with measurement systems.

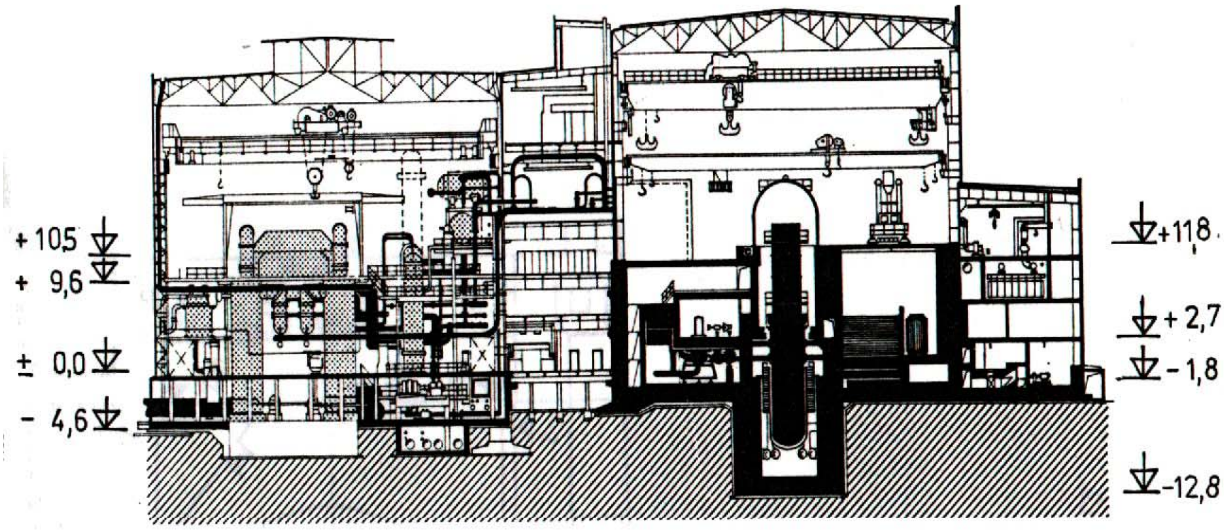

Figure 2 Crossection MOB of the plant with measurement systems

For hydrolevelling and pendametric measurements of observed points in reactor hall were used the measuring systems of the Institute of Measurement SAV : Nivelomat PC, Vertimat PC and Pendameter - Figure 3.

3. DATA PROCESSING

A complete data processing is realised according to particular steps. Nowadays we have been realising 2 measurements during the operation of the NPP and 1 stage during its lay-off. For processing we use the PC and a special sotwareVLS (vertical local control network), version 2.0 developed in 1991 by M. Klobušiak, Ph.D, which according to our knowledge is one of the best in Europe.

The processing and adjustment on particular levels of the NPP proceeds independently, when in the first step the levelling loops are adjusted according to the optimal plans of measurement and in the second one they are adjusted according to the transfer of the height on the particular level.

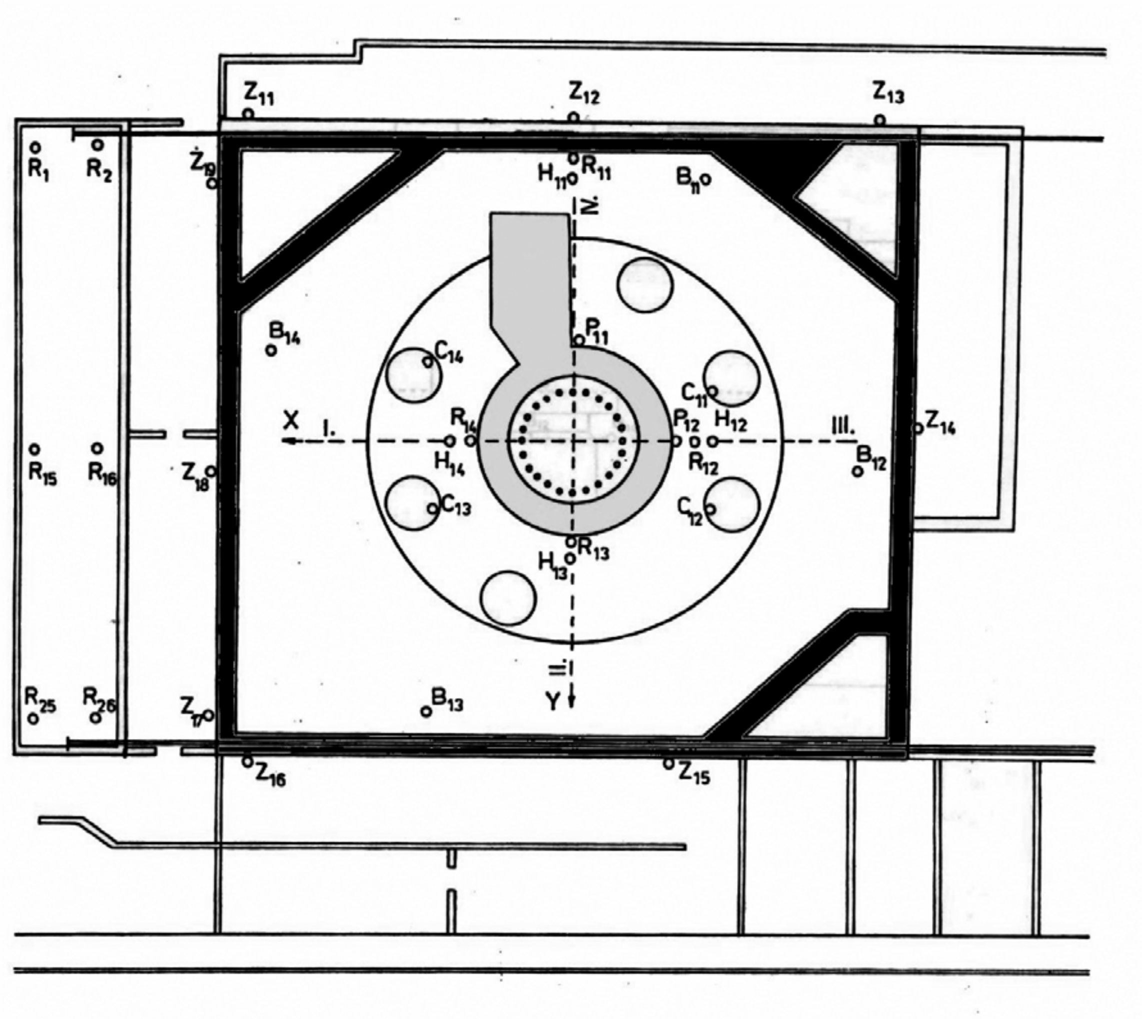

Figure 3 Distribution of observed points in the reactor hall

The results – adjusted heights of points are compared with the results of previous epochs and that of the zero epoch levelling. The report measurement consist from overwiev fieldsketches of observed points inc. an optimal design of measurement, temperature values, characteristic of operational conditions and also copies of calibration records of instruments used (Lukáč et al., 1991-2001).

The vertical displacements of structures depend mainly on physical qualities of the foundation soil and on such accidental factors like the temperature inside the object, the temperature and humidity of the foundation soil, ground water level etc. disturb their theoretical development in time. And namely by the determination of the dependency of the vertical displacement on accidental factors by the methods of mathematical statistic is one of the most important tasks for the contemporary research of deformations of structures. Such approach to the analysis of results of long periodical measurements gives a more complete view of deformation processes mentioned.

Therefore we utilise for the prediction of the deformation development such type of prognostic methods which start from the assumption that the key for the future is the past a.e. by a more or less complicated mathematical apparatus the future is predicted according to the historical development of the predicted phenomenon. These types of methods are applied very often in the prognostic practice. A typical representative of them is the ,,multi factor correlation analysis", which we applied for the prediction of deformations at some selected structures of NPP Bohunice. The discussions about the predicted values with professionals for foundation and static design proved that the prediction of deformation processes based on long periodical surveying measurements is the most credible.

Graphical presentation of vertical displacements at selected NPP structures as well as the tilt of reactors is given detailed in (Michalčák et al., 1983 and Ondriš, 1996) and also in figure 4, 5, 6, 7, 8.

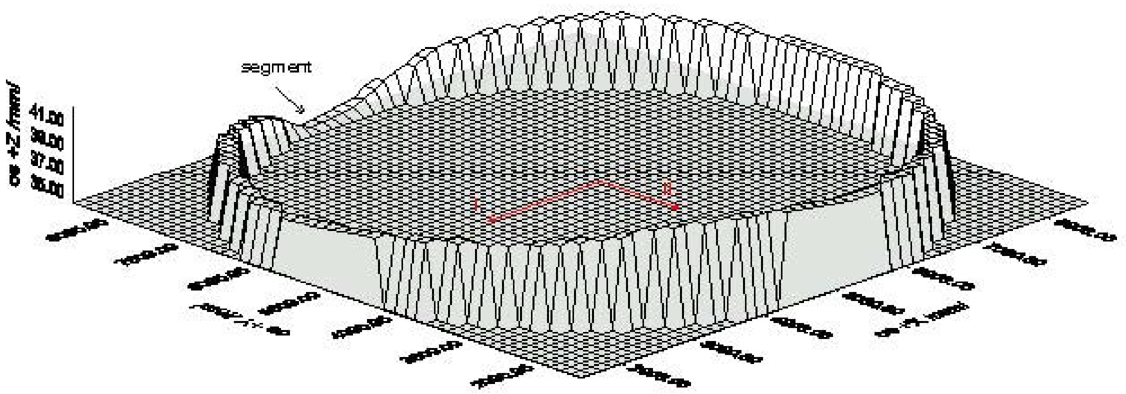

Figure 4 Graphical presentation of flange deformation of the reactor protection cove in the orthographic projection

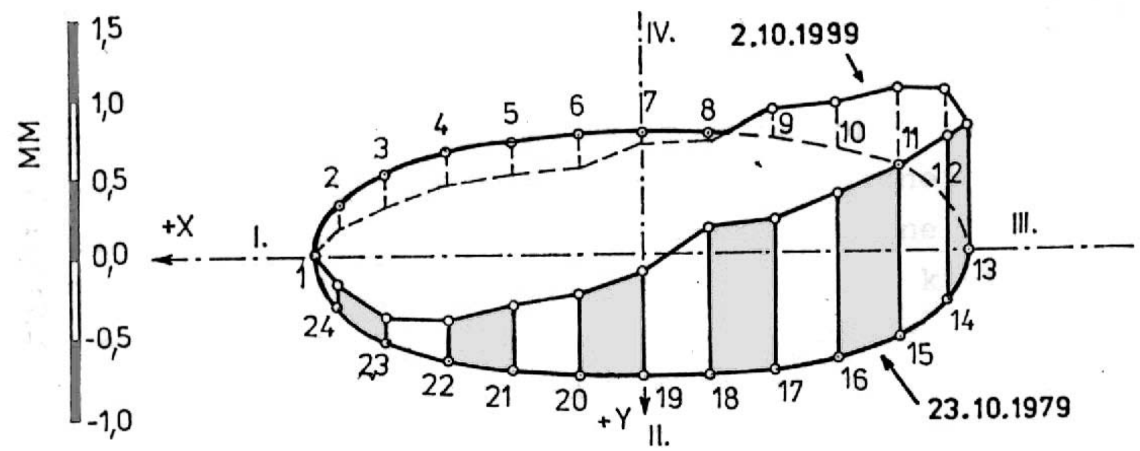

Figure 5 Presentation of vertical displacements of the reactor

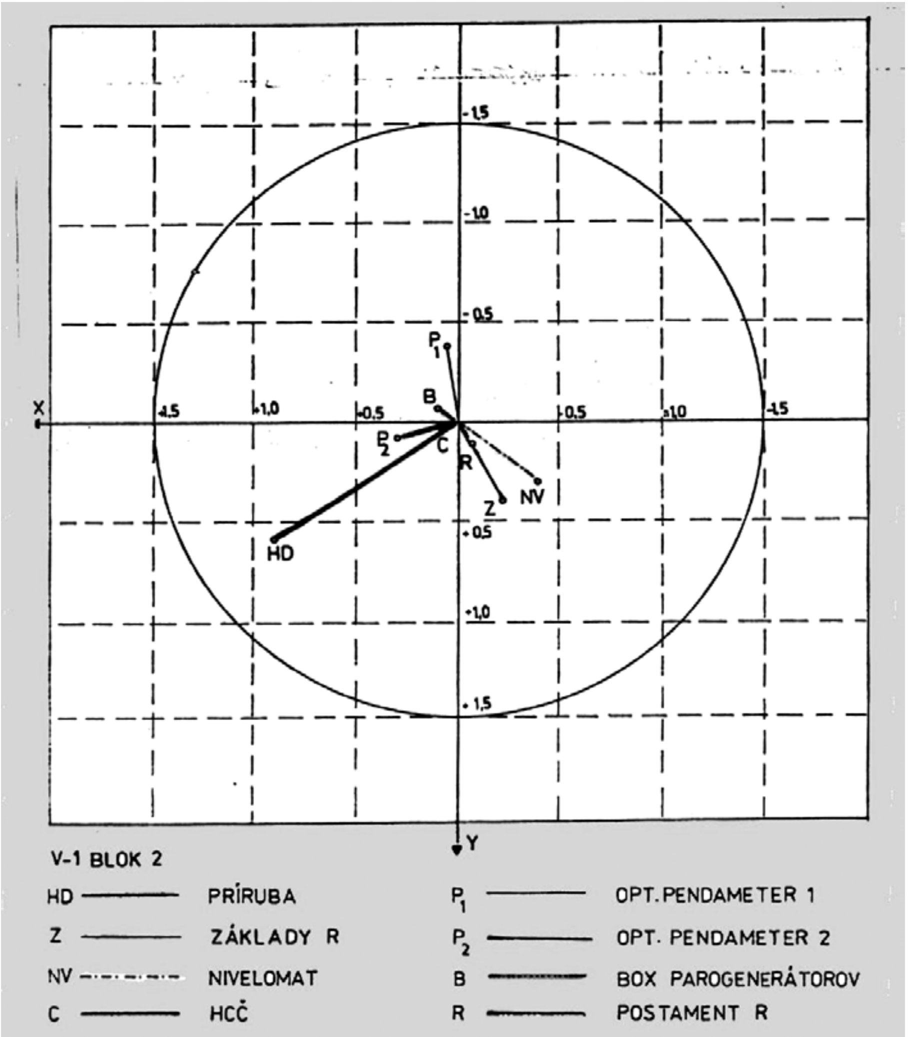

Figure 6 Vector presentation of the reactor tilt according to the individual measurement methods

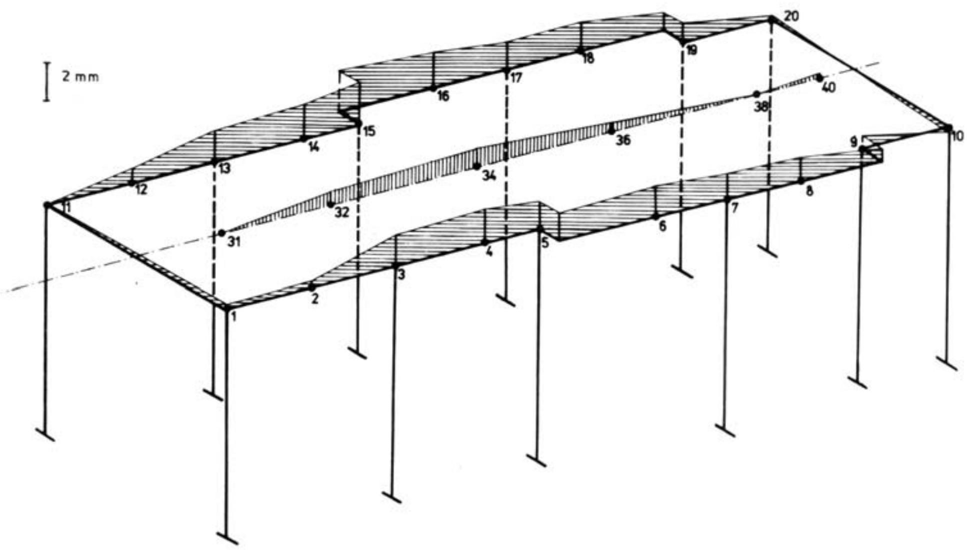

Figure 7 Axonometric presentation of the UFP with emphasis on a longitudal direction

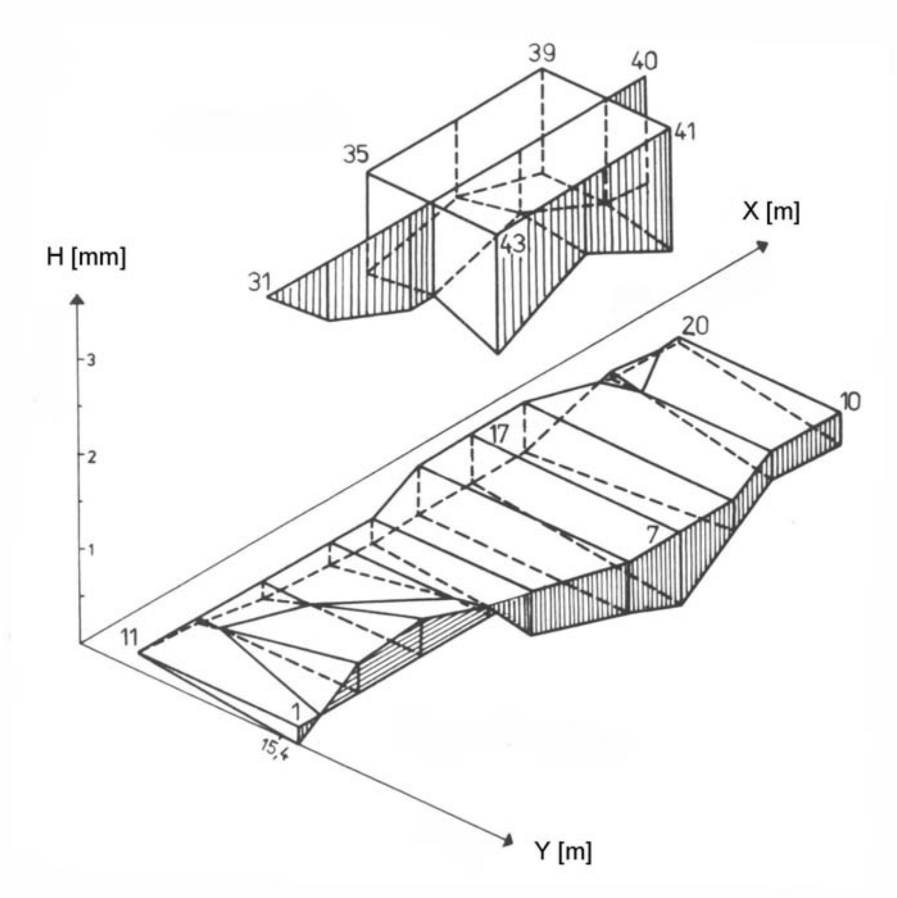

Figure 8 Axonometric presentation of the upper plane and technological part of turbogenerator deformations

4. CONCLUSION

For a complete understanding of the diagnosis of the NPP Bohunice is important not only an independent methodology requiring a precise definition of the measuring process but also adequate measuring instrumentation as well as the level of data processing based on most recent knowledge of mathematical statistics, theory of errors and adequate software.The results of measurements and monitoring of deformations at the NPP Bohunice confirm the overall good stability of its objects which has a positive impact an the reliable operation and safety of the NPP.

According to international evaluations (International Atomic Energy Agency and the World Association Nuclear Operators) as well as national supervision institutions (The Office for Nuclear Supervision) controlling the safety of nuclear resources there are not technological safety or economical reasons for lay –off the NPP-V1 Bohunice in the near future. There-fore the statements of various foreign politicians on the operation of the V-1 published in the mass media are political not professional views.

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BIOGRAPHICAL NOTES

Štefan Lukáč

Education: (1970-1975) Slovak University of Technology in Bratislava, Faculty of Civil Engineering, specialisation: Geodesy and Cartography. He attained the Certificate of authorised surveyor for engineering surveying in 1997.

Professional experience: Since 1975 he performed and managed the surveying works mainly in the engineering geodesy, since 1978 he is employed as an assistant lecturer at the Department of Surveying at the Faculty of Civil Engineering, Slovak University of Technology in Bratislava, where he gives lectures in subjects as Surveying in Industry and Professional Standards in Geodesy and besides the pedagogical, scientific and publication activities (more than 120 publications) oriented mainly to the field of geodetic works in investment construction, technical specifications and standards, performs also surveying works in engineering geodesy for external customers.

Membership in professional organisations: since 1997 he is the President of Slovak Union of Surveyors, since 1997 a member of the Directive Board of Chamber of Surveyors and Cartographers and since 2002 a Vice Chairman of Chamber Board. He is also a national delegate of the Slovak Republic for the 1st Commission of FIG since1998 and a national delegate of the Slovak Republic for the 6.1st Commission of FIG.

Ján Hardoš

Education: (1970-1975) Slovak Technical University Bratislava, Faculty of Civil Engineering, specialisation: geodesy and cartography. He attained the certificate of authorised surveyor for engineering geodesy in 1980 and for cadastre in 1992.

Professional experience: Since 1975 he performed and managed the surveying works mainly in engineering geodesy (investment construction, deformation measurement, mapping operations). In years 1985 – 1989 he acted as a Czechoslovak expert for the Ministry of Water Economy of Algeria at geodetic assurance of construction of 4 dams in North-East Algeria. Since 1993 he is the Director and joint owner of a private geodetic company SIGEO Ltd Bratislava.

Membership in professional organisations. (1990-1995) the member of chair of SUS, since 1996 a member of CSC and at the same time also a member of the Directive Board of CSC. National delegate for the 6. Commission of FIG since 1998.

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