Human resource management as an element of sustainable nuclear power plant construction

Andrey Morozenko and Natalia Shvets
Moscow State University of Civil Engineering, 26, Yaroslavskoye shosse, Moscow, 129337, Russia

Abstract. The widespread development of the trend towards sustainable construction processes is associated with two key determinants: environmental friendliness and resource efficiency. The focus is usually made on resource efficiency of already constructed buildings as the building maintenance life cycle accounts for up to 80 per cent of all costs. The need to improve the training level of civil engineering staff, especially in case of construction of facilities abroad, is confirmed by the building practice. There is a growing need to develop and adapt the industry-wide entry control mechanism allowing to test qualification and professional level of construction staff in order to barometer job applicants and secure their due training depending on the qualification level. This approach makes it possible to minimise the costs of staff turnover, exclude construction stoppages due to staff-induced fault as well as to bring down the number of accidents, which will have a significant impact on assessment of NPP construction efficiency.

Keywords: construction process sustainability; resource efficiency; nuclear power plants (NPP); construction and assembly staff; human resource professional training; labour market pressure index; staff qualification verification test; ensuring safety of construction; staff potential.

1 Introduction

The Engineering Division of ROSATOM is in the process of construction of 25 NPP power units in 9 countries of the world, being an international leader in the number of simultaneously erected power units [1]. The map of Rosatom’s construction projects presence demonstrates a tendency in the developing countries’ civil engineering characterised by improper qualification of professional staff.

Rosatom, meeting its contractual obligations in NPP construction, creates new jobs and is engaged in transfer of construction technologies and, at the same time, of educational programmes for the staff involved in NPP construction.

The efficient solution of this task is impossible without studying and generalising staff training approaches and practices; improving the workforce potential level; monitoring employees’ main characteristics as an element of the socio-productive process aimed at realising the target function of a civil engineering organisation.

1 Corresponding author: morozenkoaa@mgsu.ru

© The Authors, published by EDP Sciences. This is an open access article distributed under the terms of the Creative Commons Attribution License 4.0 (https://creativecommons.org/licenses/by/4.0/).
At the same time, the process of industry staffing should be continuous and sustainable. Otherwise, it would not be able to meet the current needs of a production complex at all phases of the life cycle of a facility, as well as operation of technically complex and unique construction objects.

The term ‘sustainable development’ was first introduced in the 1987 Brundtland report, defined as the ability to meet all people’s needs at present without compromising the ability of future generations to meet their own needs [2].

The work process at Rosatom is based on the policy of sustainable development and principles of social responsibility. The company contributes to the development of the economy and infrastructure of the countries where it operates, ensuring long-term utilisation of production facilities, improving the living standards and creating a significant number of jobs. Since 2020, ROSATOM has been a member of the UN Global Compact, a largest international UN initiative for business in the field of corporate social responsibility and sustainable development [3].

The term ‘sustainable construction’ has become the construction industry’s response to the realisation of sustainability goals.

Professor Charles J. Kibert defined sustainable construction in 1994 at the final session of the First Conference of CIB TG 16 on Sustainable Construction as “the creation and responsible management of a healthy built environment based on resource-efficient and ecological principles” [4].

In the United States, the Environmental Protection Agency (EPA) defines sustainable construction as “the practice of creating structures and using processes that are environmentally responsible and resource-efficient throughout the entire life cycle of a building from siting to design, erection, operation, maintenance, renovation and demolition” [5].

The sustainable construction concept includes protection of environment, use of environmentally friendly materials, introduction of a resource reuse cycle and implementation of cost analysis aimed to minimise expenses throughout the object’s life cycle.

The issues of sustainable construction concept development have been considered by a team of authors supervised by Bairamukov S.Kh. [6], Khallyev B. [7], Tetyor A.N. [8]; meanwhile the housing construction trend issues in terms of sustainable construction have been studied by Afanasyeva A.N. [9] and Kemenov D.A. [9].

The approaches to the realisation of sustainable construction principles from the ecological point of view have been explored by a team of authors headed by Zhukov A.D. [11]; the issues of sustainable development of construction as treated in the UN resolution have been highlighted in a study by Aleksanin A.V. [12]; sustainable development in power engineering has been considered by S.B. Sborshchikov [13]; the role of sustainable construction in improving competitiveness of world economy entities has been considered by Begadze G.Sh.[14]; the aspects of sustainable development of the country have been addressed by the team guided by Stroganov V.F. [15].

The issues of housebuilders’ and installation fitters’ training for NPP construction have been considered by a team supervised by Opekunov V.S. [16].

According to the authors of the present article, a sustainable process of any origin is a process involving a renewable resource. This applies as well to industry staffing. It is impossible to imagine a durable life cycle of a developing system without renewal of its elements if their life cycle is shorter than that of the system. Therefore, the main condition of sustainability of a system is preservation or renewal of its resource component.

The following conclusions have been drawn on the basis of the analysis:

1 The definition of the term ‘sustainable construction’ has not been considered in the analysed sources relative to the construction of NPPs.
2. The considered studies contain no analysis of the construction industry labour market as an element of macroeconomic conditions for the development of sustainable construction.

3. The articles do not consider the methodology for entry control of human resource qualification and industrial training at construction enterprises as a tool to improve resource efficiency as one of the principles of sustainable construction.

2 Materials and methods

One of Rosatom’s projects is El Dabaa NPP being erected in the Arab Republic of Egypt, consisting of 4 power units with VVER-1200 reactors (generation 3+). According to the contract, the Russian party will not only build the plant but will also supply Russian nuclear fuel for the entire life cycle of the nuclear plant and will also assist the Egyptian partners in staff training and support in operation and maintenance thereof during the first 10 years of its operation [17].

According to the forecast calculations, the simultaneous construction of 4 power units during peak periods will require about 28 thousand people to work as construction and installation staff (Fig.1), with 85% of them represented by the local staff.

![Fig. 1. Forecast of changes in the numbers of construction and installation staff.](image)

To assess the possibility of providing the project with construction and assembly staff, it is worthwhile to analyse a number of reference indicators reflecting the macroeconomic situation in the country.

According to the Egyptian government statistics as of February 2023, a record-low unemployment rate of 7.1 p.p. was fixed in the country (Figure 2).

![Fig. 2. Unemployment rate dynamics in the Arab Republic of Egypt in 2017-2023.](image)

The low unemployment rate in the country can be regarded both as a positive trend and as an indicator characterising the emerging staff shortage in the labour market, including in
the construction cluster involving about 15% of the able-bodied male population (about 4.8 million people).

In order to confirm this hypothesis, it is worthwhile to undertake an analysis of labour market pressure in the construction industry. The results are presented in Table 1.

Table 1. Analysis of labour market pressure in Egypt's construction industry.

<table>
<thead>
<tr>
<th>Occupation / year</th>
<th>2019</th>
<th>2020</th>
<th>2021</th>
<th>2022</th>
<th>As of 01.08.2023</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total vacancies in the construction and housing utilities sector</td>
<td>58,435</td>
<td>61,443</td>
<td>63,286</td>
<td>70,549</td>
<td>125,981</td>
</tr>
<tr>
<td>including job positions critical for NPP construction</td>
<td>17,783</td>
<td>18,410</td>
<td>19,667</td>
<td>21,890</td>
<td>32,728</td>
</tr>
<tr>
<td>Foreman</td>
<td>6,872</td>
<td>7,012</td>
<td>7,586</td>
<td>8,256</td>
<td>12,487</td>
</tr>
<tr>
<td>Installation fitter</td>
<td>4,256</td>
<td>4,159</td>
<td>4,398</td>
<td>5,327</td>
<td>8,560</td>
</tr>
<tr>
<td>Concrete worker</td>
<td>2,634</td>
<td>2,943</td>
<td>2,993</td>
<td>3,156</td>
<td>4,934</td>
</tr>
<tr>
<td>Welder</td>
<td>2,386</td>
<td>2,531</td>
<td>2,938</td>
<td>3,212</td>
<td>4,230</td>
</tr>
<tr>
<td>Fitter</td>
<td>793</td>
<td>862</td>
<td>815</td>
<td>937</td>
<td>1,208</td>
</tr>
<tr>
<td>Crane operator</td>
<td>842</td>
<td>903</td>
<td>937</td>
<td>1,002</td>
<td>1,309</td>
</tr>
<tr>
<td>Increase in the number of vacancies compared to the previous period, %</td>
<td>-</td>
<td>4.9</td>
<td>2.9</td>
<td>10.3</td>
<td>44</td>
</tr>
<tr>
<td>Number of CVs in the construction and housing utilities sector</td>
<td>401,50</td>
<td>413,92</td>
<td>398,00</td>
<td>427,95</td>
<td>541,718</td>
</tr>
<tr>
<td>Increase in the number of CVs compared to the previous period, %</td>
<td>-</td>
<td>3</td>
<td>-4</td>
<td>7</td>
<td>21</td>
</tr>
<tr>
<td>Labour market pressure index</td>
<td>6.9</td>
<td>6.7</td>
<td>6.3</td>
<td>6.1</td>
<td>4.3</td>
</tr>
</tbody>
</table>

As follows from the results presented in Table 1, the workforce market for the construction and utilities sector in Egypt is becoming increasingly tight. The global trends towards urbanisation and industrialisation, investment in railways, roads, ports, power engineering and housing utilities around the world and in Egypt are driving the growth of the construction sector [18]. At the same time, there is a gap between the supply represented by job candidates and the demand of employers. As an example, in August 2023 the number of vacancies in the construction sector increased by 44% compared to 2021, while the number of CVs in the same period increased by only 21%, pointing to staff shortage (the labour market pressure index dropped to its lowest value within the last 5 years – 4.3 p.p.).

When there is a scarce resource (employment candidates) against a demand for this resource (increased number of vacancies in the construction industry), companies will seek to take the potential candidates on the staff. It should be noted however that labour productivity does not grow in this case as the candidates’ professional competency level does not meet the required profile, which does not let the construction industry develop in accordance with the key principle of sustainable construction – resource efficiency.

In exploring the root causes of the presented trends, the following should be noted:

1. The educational infrastructure in the country is not focused on mass training of construction and assembly staff which would be supposed to master due professions enabling the further specialists to work in industrial construction, which prevents a greater number of candidates from applying for jobs in the industry.
2. The employees with primary civil engineering education / having experience in civil construction do not have due skills in erection of industrial facilities and use of unique technological solutions to be applied in nuclear construction.

3. In virtue of the low wage level in the sphere of construction countrywide, skilled labour resources relocate to projects realised in other countries providing them with higher earnings.

3 Results

According to the August 2023 data, a total of 25.6% of the country residents have higher and incomplete higher education, 35.4% have secondary vocational education, 32.3% have completed 5, 9, 11 years of school education, and the rest have no education / are illiterate [19].

Considering that nuclear power plants represent technologically complex construction; considering the requirements of construction contracts in terms of providing a construction project with employees of due qualification; considering that the work process should be based on the principles of sustainable development and sustainable construction, the Engineering Division of ROSATOM State Corporation has formed due approaches to the labour-market staff qualification control and the workers’ on-the-job professional training.

The entry control is made for 4 most popular professions – fitter, concrete worker, welder, installation fitter, and for auxiliary secondary occupations – carpenter, crane operator and other. The methodology of entry qualification control is based on the developed competence model by types of work, check list for assessment of theoretical knowledge, control test for evaluating practical skills with a score-based assessment of results, including in terms of work safety. The schematic algorithm of actions in the realisation of entry control and industrial training methodology is presented in Fig. 3:

![Diagram of entry control and industrial training methodology](image_url)

**Fig. 3.** Methodology of entry qualification control and industrial training of local staff at NPP “El Dabaa” construction site.
The application of the proposed methodology meets at once several challenges faced by Rosatom, namely: increasing the labour resource efficiency, ensuring safety and minimisation of accidents during NPP construction, transfer of educational products, application of unique technological solutions that are impossible without the required qualification level of local construction staff.

The results of entry control of local staff qualification in 2022 and 7 months of 2023 in accordance with the presented methodology are reflected in Table 2.

Table 2. The results of entry control of local staff qualification in 2022 and 7 months of 2023.

<table>
<thead>
<tr>
<th>Profession</th>
<th>Total number of entry control participants</th>
<th>Number of workers that passed entry control</th>
<th>Number of workers that failed entry control</th>
<th>% of workers that passed entry control</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1 qualification grade</td>
<td>2 qualification grade</td>
<td></td>
</tr>
<tr>
<td>Fitter</td>
<td>2,821</td>
<td>1,208</td>
<td>718</td>
<td>895</td>
</tr>
<tr>
<td>Concrete Worker</td>
<td>1,399</td>
<td>433</td>
<td>387</td>
<td>579</td>
</tr>
<tr>
<td>Welder</td>
<td>757</td>
<td>257</td>
<td>262</td>
<td>238</td>
</tr>
<tr>
<td>Carpenter</td>
<td>416</td>
<td>210</td>
<td>113</td>
<td>93</td>
</tr>
<tr>
<td>Total:</td>
<td>5,393</td>
<td>2,108</td>
<td>1,480</td>
<td>1,805</td>
</tr>
</tbody>
</table>

Thus, 39.1 per cent of 5.3 thousand applicants passed the qualification entry control for award of the 1st qualification grade (unskilled workers) and 27.4 per cent – for award of the 2nd qualification grade. At the same time, one third (33.5%) of the applicants did not pass the entry control even for unskilled worker’s qualification.

The lowest percentage of those who passed the entry control was registered for concrete workers (58.6%). This is because the specifics of work with monolithic concreting during standard construction in civil engineering differs, for instance, from the concreting technology needed for a nuclear island body; therefore, the local applicants do not have professional competences in the field of nuclear construction.

4 Discussion

In order to meet contractual obligations and allow local staff to work independently as part of work crews, Rosatom organises entry control of qualification, professional training, compliance with occupational health and safety standards as well as professional development.

It should be noted that the proposed and already tested methodology of staff selection and training can be applied by enterprises of various industries and host countries with necessary adaptation to local legislation requirements.

The achievement of sustainable construction goals and efficient use of resources is impossible without yielding maximum gain from the use of labour resources since the efficiency of applied technologies and equipment as well as the absence of work stoppages caused by violation of safety standards and construction quality depends undoubtedly on the competence of staff engaged in the work.

Talking of resource efficiency, it should be noted that at present the transition to cost-efficient construction takes place not through minimisation of construction costs but through reduction of operating costs [20]. This confirms the need to organise staff management through qualification entry control and due professional training in order to increase productivity and minimise the costs at the stage of erection.
5 Conclusions

Constructing nuclear power plants according to the principles of sustainable construction means not only new technological solutions and environmental safety. It supposes efficient use of resources, in the first place – labour resources which, reinforced by a systematic approach to assessment and professional development, will ensure NPP construction in compliance with all safety requirements and standards, which will make it possible to operate a NPP safely for the mankind for at least 60-80 years.

It is difficult to overestimate the importance of the methodology for assessing the qualification and professional training of construction and assembly local staff, since it allows to select workforce having due professional knowledge and, proceeding from the level of the workers’ initial professional qualification, to choose the optimal professional development track for them and to form efficient labour teams.

References

7. B. Khalilova, M. Gurbanlyyov, S.Begpoladov, Bul. Sci. 5(6(63)), 494-498 (2023)
