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Reasons for Applying Innovations for Scaffolding Work

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Reasons for Applying Innovations for Scaffolding Work

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In this paper reasons for applying and for not applying technical and organisational innovations in scaffolding work are studied. In a participatory ergonomic approach these innovations were developed to reduce problems concerning physical load of scaffolders. In this study reasons for the adoption of the innovations in the scaffolding sector are evaluated in 2 studies, in 48 companies.

More than half of the scaffolding sector in the Netherlands adopted the innovations. Reasons for applying innovations concerned improvement of work and health and satisfaction with usage. The reason for not applying the innovations concerned specific situations, such as offshore work, in which innovations were not applicable.

scaffolding work innovations participatory ergonomics
musculoskeletal problems construction industry

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1. INTRODUCTION

Scaffolding work is physically demanding (Vink, Urlings, & Molen, 1997). In 1996 sick absenteeism of scaffolders was at the level of 8.6%. This is far above the Dutch average in the construction industry, which is 5.1% (Economisch Instituut voor de Bouwnijverheid [EIB], 1999). Seven percent of 2,756 scaffolders were disabled in 1995–1998 (EIB, 2001). More recently, the rate of sick absenteeism and disability has been lower, but the total cost of sickness disablement in the construction industry has been estimated at the minimum of €700,000 per year (Koningsveld & Thé, 1999). A large part of sick absenteeism and disability is caused by work or has happened during work.

Musculoskeletal problems constitute 64% of the causes of disablements (EIB, 2001). A survey of the Periodical Work and Health Research (PAGO) in 1998/99 carried out amongst 60,000 workers in the construction industry showed that 80% of scaffolders experienced their work as physically highly demanding (Arbouw, 2000). Musculoskeletal complaints in the back are reported by 46% of the scaffolders, complaints in the arms by 37%, and complaints in the shoulders by 28%. Scaffolders report that 46% of these complaints are caused by work (Arbouw, 2000). These numbers are also higher than the average in the construction industry (see Table 1).

TABLE 1. Musculoskeletal Complaints of Scaffolders Compared With the Construction Industry in General, According to PAGO Research in 1998/99 Conducted Amongst 60,000 Workers in the Construction Industry (Source: Arbouw, 2000)

Musculoskeletal Complaints	Scaffolders (%)	Construction Industry (%)
Experienced work-related physical discomfort	80	55
Musculoskeletal complaints		
Back disorders	46	36
Arms	37	24
Shoulders	28	18
Percentage of work-related complaints	46	32

Notes. PAGO—Periodical Work and Health Research.

According to Burdorf and Sorock (1997), lifting or carrying loads, frequent bending and twisting the back as well as whole-body vibration are important physical load risk factors consistently associated with work-related back disorders. Both lifting and carrying loads, and bending and twisting the back

are frequently seen in scaffolding work. Most worktime (47%) is used to erect scaffolding, 18% to dismantle it, and 20% for horizontal and vertical transport of scaffolding materials. When scaffolding is erected, scaffolders work 27% of the worktime with their back bent and 30% with elevated arms (Dawson, Kleppe, Beek, Burdorf, & Elders, 1999).

To reduce these risk factors, a participatory project was carried out to develop technical and organisational innovations. This participatory process is described in detail in Vink et al. (1997). For horizontal transport a palletcart (see Figure 1) was developed. The palletcart is to reduce the load during horizontal transport, because scaffolding materials do not have to be carried on the shoulders. For vertical transport, a truck with ladders and an electrical whinch fixed on the facade of the building (see Figure 2) were suggested.

Figure 1. A palletcart, which eliminates horizontal transport of materials on the shoulder.

These devices should eliminate manual vertical transport along the scaffolding. Alternatives for vertical transport were also developed in other projects. These concern the use of a construction crane, a construction elevator, a hoist-and-tackle, or a truck with a special device to place materials directly on the scaffolding up to the fourth floor. To reduce the weight of the scaffolding materials, shorter ladders and shorter boards were suggested in the participatory project. To improve personal protection against pressure on the shoulders, shoulder pads were suggested. For safety reasons a safety harness, which is available on the market, can be used for personal protection.

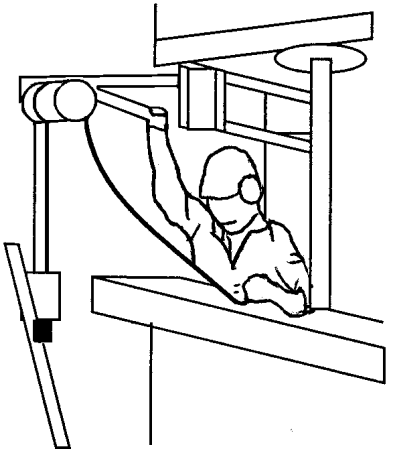

Figure 2. An electrical whinch, which lifts materials and eliminates manual vertical transport.

The safety harness is positioned around the body of the scaffolder and from the harness ropes are locked onto the scaffolding to protect scaffolders from falling down. Organisational innovations developed in the participatory projects included setting out scaffolding materials close to the workplace in the right order (see Figure 3), (un)loading the truck in such a way that materials can be taken from the top, and cleaning scaffolding by construction workers before dismantling.

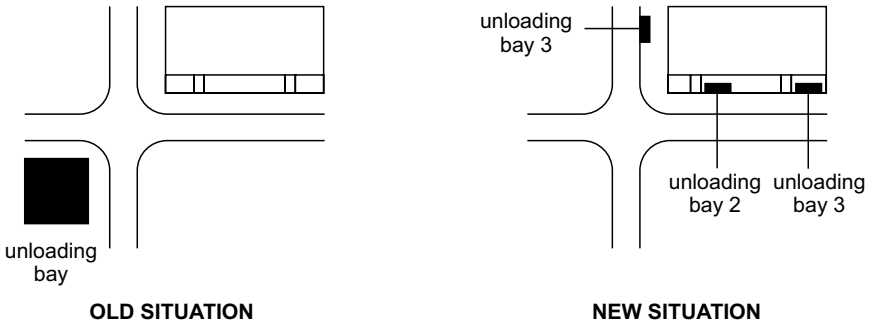

Figure 3. Setting out materials close to the workplace. *Notes.* On the left: the old situation, in which the materials are set out in one unloading bay, which results in much manual carrying due to assorting and due to manual horizontal transport. On the right: the new unloading plan, in which the materials are set out in different unloading bays close to the spot where the scaffolding will be built. This arrangement reduces assorting and manual carrying.

To increase the use of the results of the participatory project in the scaffolding sector, meetings of representatives of employers and employees were set up at work to promote the use of the innovations in a special guideline, a so-called A-document (A for Arbouw). This A-document, issued by the sector organisation for the construction industry in the Netherlands (Arbouw) includes guidelines for maximum acceptable loads and advice how scaffolding companies can apply the innovations. Apart from the A-document, the results of the participatory approach was communicated to the scaffolding sector in several publications in sector magazines. Written instructions how to carry out a participatory process to improve work in the scaffolding sector was sent to all institutes for working conditions in the Netherlands. Also, several nontraceable personal communications took place at meetings and exhibitions.

Six months after the end of the project, a process evaluation was carried out in one of the participating companies. This evaluation showed that 30–88% (percentage depending on the type of innovations) of the scaffolders were working with the innovations (Vink et al., 1997). Furthermore, the effects of the improvements on physical workload were tested in the evaluation. The use of a palletcart, an electrical whinch, shortened ladders and boards, and shoulder pads significantly reduced heart rate. Manual carrying and manual lifting were also significantly reduced due to the innovations (see Figure 4).

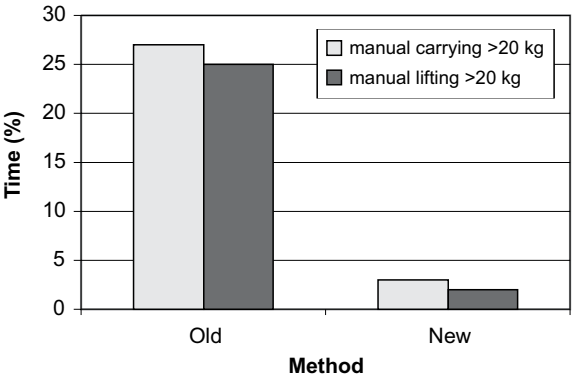

Figure 4. Percentage of time when scaffolders are observed with more than 20 kg in their hands during the old and new method. *Notes.* Source: Vink, Urlings, and Molen, 1997.

The previously mentioned Dawson et al.'s (1999) study of 61 scaffolders of a scaffolding company showed that the innovations for scaffolders were only used during 2% of worktime. This was partly caused by the fact that the innovations were not suitable for use in small and inaccessible places in industrial settings. However, they did conclude that complaints concerning the back and shoulder decreased when the innovations were used.

From a scientific viewpoint and for sector organisations there is a need to know to what degree innovations are applied in the scaffolding sector and the reasons for applying or not applying the innovations. This is necessary in order to gain knowledge on improving the adoption of the innovations in the sector.

The main questions of this study are as follows:

- What are the underlying reasons for applying or not applying innovations to improve scaffolding work? and
- What are the experiences of users of innovations for scaffolders?

2. METHODS

To study the reasons for adoption, two separate evaluations were carried out. Both studies took place 6 years after the participatory project in which the majority of the innovations were developed. The goal of the first study was to determine the adoption of all available innovations for scaffolders in the sector and to find reasons for not applying the innovations. The goal of the second study was to study the innovations developed in the participatory project 6 years before to find out which innovations have been adopted and find reasons for applying them.

In the first study, 200 randomly selected scaffolders and 38 managers of scaffolding companies in the sector were asked to complete a questionnaire. The questionnaire of the first study asked questions on

1. The frequency of use of technical and organisational innovations on a scale from 1 (*almost never*) to 2 (*sometimes*) to 3 (*almost always*);
2. Experiences with the use of technical innovations on a scale from 1 (*very unsatisfied*) to 5 (*very satisfied*);
3. The reasons for not using the innovations and on whether nonusers would like to use the innovations.

Similar questionnaires were sent to scaffolders and managers of scaffolding companies.

In the second study 25 companies (with more than 10 employees) registered at the sector organisation were selected. In total, 55 scaffolding companies are registered at the sector organisation. They represent about 60% of the scaffolding sector. Of the 55 companies, 25 companies perform scaffolding activities. The other 30 companies are, for instance, suppliers of scaffolding materials. The management of the 25 companies was asked to complete a questionnaire. The questionnaires of the second study asked questions on

1. The adoption of technical and organisational innovations (*yes—no*) and the frequency of use of technical innovations on a scale from 1 (*daily*) to 2 (*weekly*) to 3 (*monthly*);
2. Experiences with technical and organisational devices in terms of satisfaction (*very satisfied—satisfied—moderately satisfied—not satisfied*) and on the reduction in physical load (*yes—no change—no*);
3. The reasons for applying the innovations.

3. RESULTS

3.1. Response

In the first study 102 scaffolders (response rate: 51%), of which 95% were actual scaffolders, 3% were scaffolders' assistants, and 2% were foremen, completed the questionnaire. Thirteen managers (response rate: 34%) completed the questionnaire. The size of the scaffolding companies varied (the average number of employed scaffolders was 69, $SD = 91$; the range of employees of the scaffolding companies was 0–300).

In the second study 14 managers (56%) completed the questionnaire. All managers knew that the innovations existed. Seven managers indicated that they also performed scaffolding work in the process industry (e.g., in petrochemical plants).

3.2. Adoption

All respondents of the first study used one or more of the innovations. The percentages of adoption of the technical and organisational innovations indicated by scaffolders and managers are shown in Figure 5.

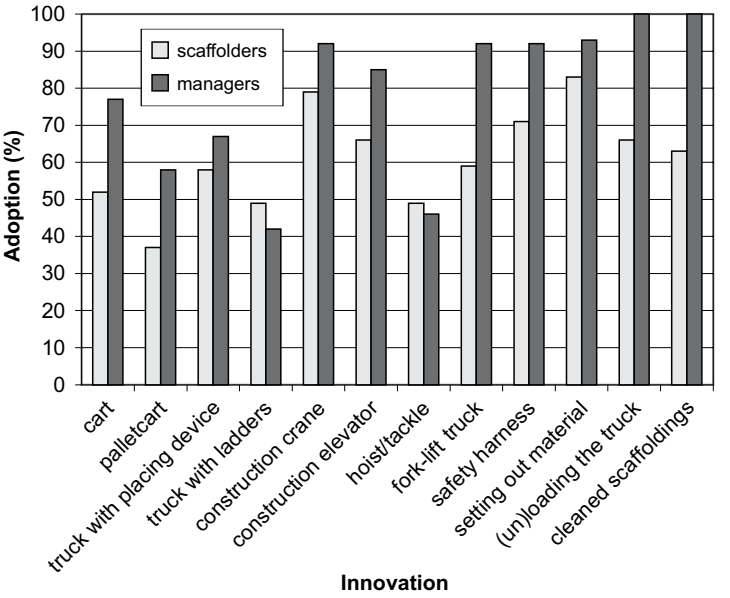

Figure 5. Percentage of questioned scaffolders and managers who report using technological and organisational innovations *sometimes* and *almost always* in the first study.

According to more than half of the managers of the scaffolding companies, most innovations were used in scaffolding work, except the truck with ladders and the hoist-and-tackle. The adoption of the organisational innovations for better (un)loading of trucks and cleaned scaffolding were indicated by all managers. The majority of the scaffolders themselves indicated that they used all innovations, except the palletcart. The problems with the palletcart, reported by scaffolders, concerned the difficulty of use in offshore work and rough terrain conditions.

In general, managers indicated a higher adoption of the innovations than scaffolders did, except for the hoist-and-tackle and the truck with ladders.

Three quarters of the scaffolders who did not use the innovations indicated that that they would like to use them.

Figure 6 shows how often technical and organisational innovations indicated by scaffolders in the first study were used.

Half or more of the scaffolders used all innovations *sometimes* or (*almost*) *always*, except for the palletcart; 5–30% of the scaffolders indicated that they *always* used the innovation. The safety harness was most often used: 67% of the scaffolders indicated an *almost always* use.

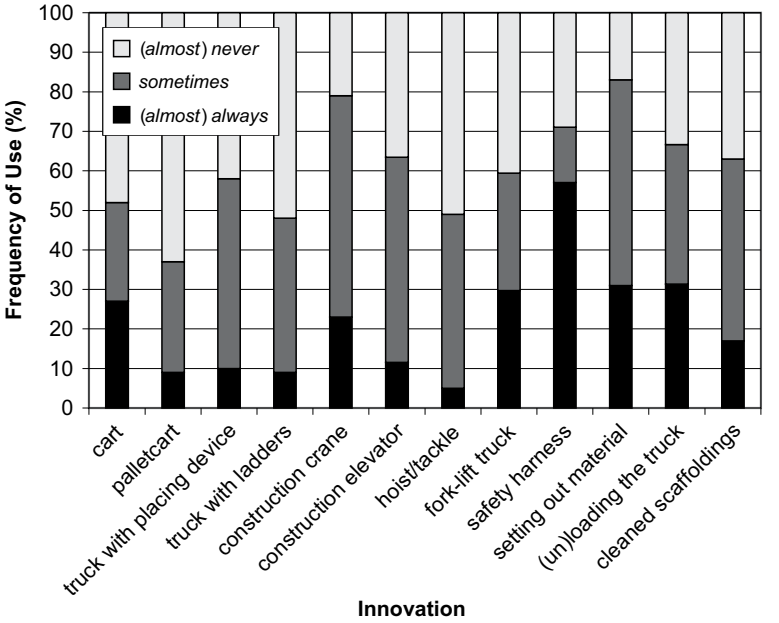

Figure 6. Percentage of questioned scaffolders who report using technological and organisational innovations (*almost*) *never*, *sometimes*, or (*almost*) *always* in the first study.

All managers in the second study indicated that they adopted one or more of the innovations. Figure 7 shows the percentage of adoption of technical and organisational innovations in the second study.

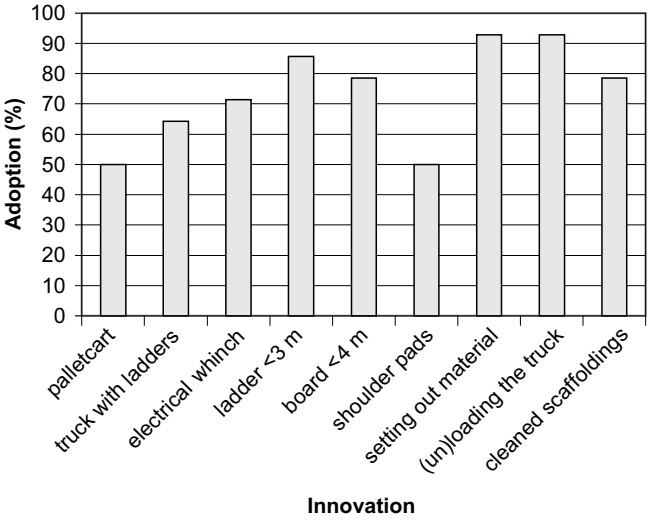

Figure 7. Percentage of questioned managers who adopted technological and organisational innovations in the second study.

Half or more of the managers of the scaffolding companies used the innovations resulting from the participatory approach. Setting out materials close to the workplace and better (un)loading of trucks were adopted by nearly all respondents. Managers indicated that the main contractor's other devices were also used, such as construction elevators and trucks with a far-reaching device.

Figure 8 shows the frequency of use of the technical innovations indicated by management.

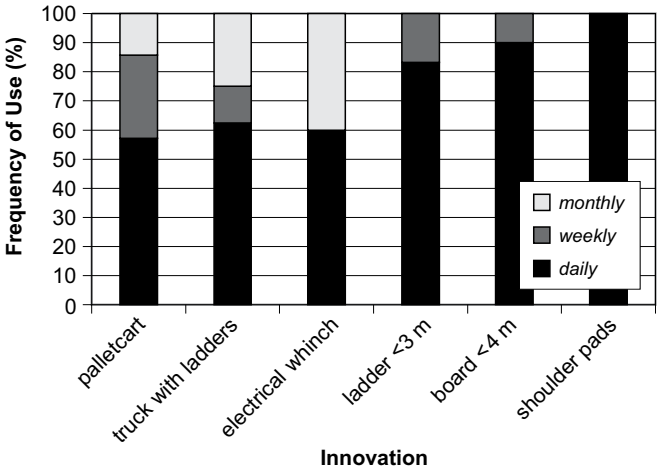

Figure 8. Percentage of questioned managers of scaffolding companies who report using technological innovations in companies *daily*, *weekly*, or *monthly* in the second study.

All innovations were used daily according to more than half of the managers. Shoulder pads were used daily according to all managers in the second study.

3.3. Experiences of Users

All managers in the first study indicated that they were *somewhat* to *very satisfied* with the innovations, except for the safety harness (25% are *unsatisfied*) because it was heavy and not easy to use. Scaffolders were also positive: A large majority (more than 80%) were *satisfied* with the innovations. They were however less positive on the use of the safety harness for similar reasons as the managers indicated and because it disturbed work. Table 2 shows the satisfaction of scaffolders with the innovations in the first study.

TABLE 2. Satisfaction of Users of the Innovations for Scaffolders (*Sometimes* and *Almost Always*) According to Scaffolders in the First Study

Innovations	*N*	*Very Unsatisfied* (%)	*Somewhat Unsatisfied* (%)	*Somewhat Satisfied* (%)	*Satisfied* (%)	*Very Satisfied* (%)
Cart	53	0	5.7	39.6	43.3	11.3
Palletcart	36	0	2.8	41.7	47.2	8.3
Truck with placing device	55	1.8	0	16.4	30.9	50.9
Truck with ladders	48	2.1	2.1	14.6	47.9	33.3
Construction crane	79	0	2.5	20.3	29.1	48.1
Construction elevator	66	3.0	6.1	31.8	39.4	19.7
Hoist-and-tackle	49	8.2	6.1	36.7	38.8	10.2
Fork-lift truck	57	0	0	15.8	47.4	36.8
Safety harness	70	12.9	7.1	27.1	34.3	18.6

Notes. N—the number of users indicating satisfaction. Satisfaction is indicated on a scale from *very unsatisfied* to *very satisfied.*

In the second study, 86% (12) of the managers indicate that they were (*very*) *satisfied* with the innovations. Fourteen percent (2) were *moderately satisfied*. None of the managers was *not satisfied*. All managers indicated that the use of the innovations reduced physical load. The problems mentioned were the necessary changes in planning when innovations were implemented. Furthermore, problems with the use of the technical innovations in small places and offshore were reported.

3.4. Reasons for (Not) Applying the Innovations

The reasons for not applying the innovations indicated in the first study concerned small working spaces in which there was no room for the innovations. Offshore the cart and the truck with ladders were not applicable. When using construction cranes, construction elevators, and hoist-and-tackles permission from the contractor could be a problem, as the contractor did not always provide those devices. When using construction elevators, scaffolders had to walk with materials on unsafe scaffolding towards the elevators, which were often too small for the materials. The hoist-and-tackle was an extra heavy load for scaffolders to carry.

In the second study, the reasons for applying the innovations were given by 8 managers. The most frequently mentioned reason for applying the innovations concerned the improvement of work and health of scaffolders. All

managers in the second study indicated that the physical load of scaffolders was reduced after the innovations were introduced. The truck with ladders was said to reduce the physical load of scaffolders best of all innovations. However, no objective measurements were done to verify these statements with scaffolders themselves.

4. DISCUSSION

The results of the first as well as of the second study suggest that technical and organisational innovations were applied by more than half of the scaffolding sector leading to satisfied users. This agrees with findings of other evaluation studies of the effect of participatory ergonomics (e.g., Garmer, Dahlman, & Sperling, 1995; Loisel et al., 2001; Wilson, 1995). However, this study has its limitations.

- Some innovations are used for similar tasks and therefore exclude each other. This may interfere with the potential total percentage of adoption, which due to this is in fact lower than 100%. For instance, the construction elevator and the hoist-and-tackle are both used for vertical transport of scaffolding material. Using both innovations does not make much sense.
- The innovations included in the two studies differ from each other, because the studies were organised for different reasons. This makes it more difficult to compare the results. However, there is a large overlap in the selection of innovations, which show similar results and provide a clear overview of the adoption of the innovations in the sector.
- A drawback of this study is the lack of data on the effects on physical load and sick absenteeism numbers in the old and new situation (with the innovations). The scaffolders were only asked about experienced physical workload when working with the innovations. However, the main goal of this study was to determine reasons for adopting or not adopting them. These reasons are of a subjective nature and data on the effects contribute less to that.
- No specific data were studied on the cost-benefit ratio. These data could be helpful in convincing companies of the need. However, information from two companies with much experience with the improvements shows that use of the electrical whinch and the truck with ladders saves time during vertical transport. However, investments are needed to buy the whinches and trucks with ladders. For horizontal transport the palletcart

saves time, but the palletcart itself must be transported, which takes more time. Positive effects were found of (un)loading the truck close to the scaffolding and in setting out materials in the right order on the site. According to both companies this saved an hour for each scaffolder.

The percentages of application of the innovations found in this study are high compared to the percentages of adoption found by Dawson et al. (1999). This is mainly due to problems applying the innovations in small workplaces such as in the petrochemical industry. In fact, these specific situations are indicated in this study as important reasons for not applying the innovations. Apparently, the companies studied in this research work less in these situations than the company studied by Dawson et al.

Another finding of this study concerns the higher percentage of use indicated by employers compared to indications of employees. The same tendency was found in the study of Loisel et al. (2001), which reported on the rehabilitation of workers with subacute back pain complaints in Sherbrooke (Canada). A participatory rehabilitation programme was started for workers to find innovations for their work in the form of a participative group with injured workers, the employer, a representative of the union, an ergonomic expert, and other stakeholders. The innovations should enable injured workers to return to their normal work. Evaluation afterwards showed that employers estimated nearly 15% higher implementation of the innovations than the employees did. An explanation suggested by Loisel et al. (2001) concerns the image of the company that is kept high and the fact that employers may give more accurate estimations than the employees.

Looking at the present study, the influence of the image of the companies is small, as there was no contact between scaffolders and scaffolding companies, and researchers (anonymous questionnaires). Here, the higher application indicated by employers over employees can be explained by differences in knowledge of the actual work situation. Employers may have overestimated the use of the innovations in practice. For instance, innovations may be present at the site, but the contractor does permit using them or they cannot be used in the specific situation. Scaffolders therefore probably provide the best estimate of adoption in terms of the frequency of use.

The most frequently mentioned reasons for applying innovations concern the improvement of work and health. The ultimate goal of the innovations was to reduce physical workload. A previous study showed objectively the effects on the reduction of workload due to improvements (Vink et al., 1997). This study is in step with these objective findings. Managers also mention

a reduction in physical workload. However, the long-term effects on complaints and sick leave require further research.

Another reason for applying the innovations for scaffolding work is found in literature. According to several studies participation may contribute to a large extent to the accepance of innovations as a result of joint problem analysis and solution finding and testing with workers (Jong & Vink, 2000; Noro & Imada, 1991; Wilson & Haines, 1997). An evaluation by Kompier, Gründemann, Vink, and Smulders (1996) of ten successful projects aimed at reducing sick absenteeism at work, including the project that is the subject of this study, showed that active involvement of workers during problem analysis and solution finding are important reasons for success. Vink et al. (1997), when evaluating the process of the participatory project of this study, indicated that active involvement of scaffolders led to useful innovations for prioritised problems. This agrees with the findings of this study, in which management was convinced of the need for innovations and scaffolders were satisfied with the use of most of them.

The most frequently mentioned reason for not applying the innovations concerns specific situations. Some innovations, despite the participatory approach, cannot be used offshore or in small workplaces (e.g., in the petrochemical industry). This agrees with the findings in Dawson et al.'s (1999) study.

In conclusion it can be said that from a scientific point of view the adoption of innovations by more than half of the companies in the sector is a fairly good result of a participatory approach.

5. CONCLUSION

This study deals with reasons for adopting technical and organisational innovations for scaffolders 6 years after a participatory project. More than half of the scaffolding companies in the sector adopted the innovations. Three quarters of the scaffolders, whose company had not adopted the innovations, indicated that they would like to use them.

Improvement of work and health is an important reason for applying the innovations for scaffolders. Furthermore, users are satisfied with the use of most innovations except the safety harness, because is not easy to use. Problems preventing the use of the innovations mainly concern work in small workplaces (the process industry, offshore).

REFERENCES

Arbouw. (2000). *Guide to work and health in the construction industry 1998/1999*. Amsterdam, The Netherlands: Author. (In Dutch).

Burdorf, A., & Sorock, G. (1997). Positive and negative evidence for risk factors of work related back disorders. *Scandinavian Journal of Work, Environment and Health*, *23*(4), 243–256.

Dawson, M., Kleppe, P., Beek, A. van der, Burdorf, L., & Elders, L. (1999, October). Stressful tasks, activities and working postures in scaffolding work: A study of the workplace. *Tijdschrift voor Ergonomie*, 134–139. (In Dutch).

Economisch Instituut voor de Bouwnijverheid (EIB). (2001). *Disability from work in the construction industry*. Amsterdam, The Netherlands: Author. (In Dutch).

Economisch Instituut voor de Bouwnijverheid (EIB). (1999). *De bouwarbeidsmarkt in de periode 1999–2004* [The labour market in the construction industry in the period 1999–2004]. Amsterdam, The Netherlands: Author.

Garmer, K., Dahlman, S., & Sperling, L. (1995). Ergonomic development work, co-education as a support for user participation at a car assembly plant: A case study. *Applied Ergonomics*, *26*(6), 417–423.

Jong, A.M. de, & Vink, P. (2000). The adoption of technological innovations for glaziers: Evaluation of a participatory ergonomics approach. *International Journal of Industrial Ergonomics*, *26*, 39–46.

Kompier, M.A.J., Gründemann, R.W.M., Vink, P., & Smulders, P.W.G. (Eds). (1996). *Let's get to work! Ten examples of succesful management of sickness*. Alphen a/d Rijn, The Netherlands: Samsom. (In Dutch).

Koningsveld, E.A.P., & Thé, K. (1999). *Costs of working conditions in the construction industry*. Den Haag, The Netherlands: Ministerie van Sociale Zaken en Werkgelegenheid. (In Dutch).

Loisel, P., Gosselin, L., Durand, P., Lemaire, J., Poitras, S., & Abenhaim, L. (2001). Implementation of a participatory ergonomics program in the rehabilitation of workers suffering from subacute back pain. *Applied Ergonomics*, *32*(1), 53–60.

Noro, K., & Imada, A.S. (1991). *Participatory ergonomics*. London, UK: Taylor & Francis.

Vink, P., Urlings, I.J.M., & Molen, H.F. van der (1997). A participatory ergonomics approach to redesign work of scaffolders. *Safety Science*, *26*(1/2), 75–85.

Wilson, J.R. (1995). Solution ownership in a participative work redesign: the case of a crane control room, *International Journal of Industrial Ergonomics*, *15*(5), 389–396.

Wilson, J.R., & Haines, H.W. (1997). Participatory ergonomics. In G. Salvendy (Ed.), *Handbook of human factors and ergonomics* (2nd ed., pp. 490–513). Chichester, UK: Wiley.