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BUILDING RESEARCH ASSOCIATION OF NEW ZEALAND

BRANZ STUDY REPORT

Cl/SfB (L44) h

UDC 691.7:620.193

SURVEY OF METAL PROBLEMS IN THE BUILDING INDUSTRY

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PREFACE

This survey is part of BRANZ's ongoing research into the durability of building materials. Results from this survey will be used to guide future research effort in the area of metals. Results will be of interest to designers, manufacturers and researchers.

ACKNOWLEDGEMENTS

The author would like to thank all those who responded to the questionnaire, and also Donal Krouse, Applied Maths Division, DSIR for his assistance with the analysis of the results.

SURVEY OF METAL PROBLEMS IN THE BUILDING INDUSTRY

BRANZ Study Report SR23

H. BROWN

REFERENCE

Brown, H.M. 1989. Survey of metal problems in the building industry. Building Research Association of New Zealand, BRANZ Study Report SR23, Judgeford.

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KEYWORDS

Aluminium, builders, coating materials, construction industry, corrosion, designers, failure, galvanised, joinery, metals, paints, steel, surveys.

ABSTRACT

A survey of selected participants across the building industry was carried out with a mail questionnaire to identify what metal problems the New Zealand building industry is experiencing. The survey indicated that problems with painted and unpainted galvanised steel, painted steel and aluminium joinery comprised a large proportion of the problems. The galvanised steel and steel problems seem due to available information not reaching (or else not being used by) those encountering problems. Further research into the performance of aluminium joinery in various environments is indicated.

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INTRODUCTION

Research on metal-based coated and uncoated building products carried out already by the Building Research Association of New Zealand (BRANZ) has included investigation into the performance of latex paints on galvanised steel (Whitney, Fry and Cordner, 1984), the performance of roof claddings (Cordner and Whitney, 1984), the adhesion of paint to galvanised steel (Duncan, 1981) and the corrosion of fasteners in CCA treated timber (Duncan, 1986). BRANZ has also published information leaflets on various metal and coating topics (Building Information Bulletins 214, 225, 249 and 253)

Enquiries about problems with metals continue to be regularly received by BRANZ on a range of topics. A wider survey was planned to verify problems encountered, and to identify the research and information requirements of the building industry.

The objectives of the survey were to find out what metal problem was most frequently experienced by respondents, what metal/coating combination(s) commonly had problems, what area of a building was most associated with metal problems, and what performance expectations were held. The results of the survey were to be used to identify those areas which require research or information dissemination to solve the more frequent problems being experienced by the industry.

THE QUESTIONNAIRE

Respondents

A mail questionnaire was designed and sent to people in various occupational groups covering the range of building-related activities (Table 1). The design of the questionnaire and advantages and disadvantages associated with this design are discussed in the appendix.

Occupational categories were used as a basis for selecting respondents to ensure that the range of interests across the building industry were represented, with people from manufacturing, tradespeople and professional occupations. Preselected respondents were used in each of these categories.

TABLE 1 Occupational Categories of Questionnaire Respondents

OCCUPATION CATEGORIES	NUMBER SENT	REPLIES RECEIVED
architects	6	2
builders	4	2
building contractors	3	1
building inspectors	3	0
engineers	6	5
researchers	9	5
consultants	9	5
industries:		
aluminium	3	3
steel&galvanising	6	1
heating&ventilating	2	1
cladding/roofing	7	3
metalfinishing/hardware	7	2
paint	7	2
stainless steel	3	1
painting contractors	2	1
plumbers&roofers	3	0
property managers	2	0
property owners	3	2
totals	85	36

QUESTIONNAIRE DESIGN

The questionnaire was divided into four general sections; an introductory section, a section dealing with metallic substrate problems, a section dealing with coating problems and a section dealing with opinions and expectations of the respondents.

The introductory section included general data about the respondents; years of experience, what building types (residential, commercial, or industrial) they were familar with, their occupation and whether their experience was with metals, coated metals or both.

The metal section, section A, was subgrouped by metal and for each metal there was a table of various building components and various building problems. Table 2 shows the common metals, building components and metal problem categories used in section A.

TABLE 2 Section A - metals, building components and problems

Metal	Building Component	Problem
aluminium	claddings	corrosion products
anodised aluminium	flashings	cracking
brass	floors	perforation
cast iron	hardware	pitting
copper	joinery	poor apearance
galvanised steel	roof	structural weakening
lead	structural	
stainless steel	walls	
steel		
zinc diecast		

The metals and building components were collated from index and content pages of building product guides (Martin, 1984 and Perry, 1986) and the various problems were collated from dictionaries and glossaries (Lesota, 1978). There was space for additional building components and problems to be added if necessary.

The coated metal section, section B, was treated in a similar fashion. For each metal there was a table of coatings and various coating problems. Table 3 shows the common metals, coatings and problem categories used in section B.

TABLE 3 Section B - metals, coatings and problems

Metal	Coating	Problem
aluminium extrusion	exterior paint	abrasion
aluminium sheet	factory applied paint	blistering
brass	interior paint	chalking
cast iron	lacquer	colour change
galvanised steel	laminate	corrosion products
lead	metal plate	cracking
stainless steel	plastic coating	crazing
steel	powdercoating	flaking
	vitreous enamel	mildew/fungi

Section C of the questionnaire examined when respondents thought a problem required attention. They were asked to answer a series of questions using an example of a metal problem and an example of a coating problem. Each question had a choice of five answers. Table 4 shows the questions and choice of replies.

TABLE 4 Section C - Questions and Choice of Replies

A problem...	Responses					
requires repair when:	problem onset	problem early stage	problem developed	failure imminent	failure occurs	
is visible from:	1 metre	5 metres	10 metres	20 metres	no answer	
is a failure if:	appearance impaired	function impaired	discomfort to users	not comply with bylaws	life/safety danger	
not before:	5 years	10 years	15 years	20 years	25+ years	

RESULTS

Appendix 1 describes the analysis of responses. Significant problems were regarded as those that were in the upper quartile of occurrences.

Figure 1 shows the degree of experience with each metal in Table 1 expressed as a percentage of all metals. There was a high proportion of experience with anodised aluminium, galvanised steel and steel.

Figure 2 shows the degree of experience with each building component for anodised aluminium, galvanised steel and steel. The shaded areas show the number of problems with each building component for the three metals. Significant problems exist with anodised aluminium joinery, galvanised steel flashings and claddings, and structural steel.

Figure 3 shows the degree of experience with each metal in Table 2 expressed as a percentage of all metals. Galvanised steel and steel have a large proportion of experience.

Figure 4 shows that significant problems exist for exterior painted and factory painted galvanised steel and exterior painted steel.

Table 5 shows the problems that were predominant with those metals identified as having problems.

TABLE 5 Metal and Coating Problems

Metals	metal problems			coating problems						
	Corrosion Product	Pitting	Poor Performance	Abrasion	Chalking	Colour Change	Corrosion Staining	Cracking	Flaking
Anodised aluminium	X	X	X						
Galvanised steel	X		X		X	X	X		X
Steel	X	X		X		X	X	X	

The results from the section dealing with performance expectations are presented in Figure 5 and the questions referred to are shown in Table 3.

DISCUSSION

Galvanised steel problems occurred mainly with claddings and flashings (Figure 2), and the coating problems with exterior paint and factory applied paint (Figure 4). Galvanised steel claddings and flashings, both site painted and factory painted are widely used throughout New Zealand in a variety of environments. Some of these environments are aggressive, not suitable for galvanised steel, and may therefore account for the high number of problems reported.

Structural steel (Figure 2) and exterior paint on steel (Figure 4) were indicated as steel problems. The coating problems are of two types: coating property problems such as chalking and abrasion or problems associated with the interaction of the coating with the substrate. Flaking, corrosion-staining and cracking of the coating can occur as the substrate corrodes. Whether corrosion caused the coating failure or the failure allowed corrosion of the substrate was not addressed in the questionnnaire.

The high proportion of problems with galvanised steel and steel may be a reflection of the corrosivity of the New Zealand environment. Ballance and Duncan (1985) report on the high levels of windborne salt in New Zealand which can accelerate corrosion when deposited on metal surfaces. Another factor that may be important in determining the corrosivity of the New Zealand environment is the high relative humidity.

The high reported number of problems with anodised aluminium joinery (Figure 2) may be related to microclimatic factors. Joinery is often in sheltered positions on a building. Dirt and salt can build up on the surfaces when the joinery is not rainwashed or cleaned. This buildup and the high relative humidities in New Zealand will accelerate corrosion of the aluminium.

The performance of anodised aluminium in New Zealand has received some study in the past (Fahy, 1983), but the performance of aluminium joinery has not been systematically examined, although problems have been documented by the Architectural Aluminium Association of New Zealand (1970). Further investigation into the performance of aluminium joinery and the effects of sheltering is indicated.

The analysis of problems by building component highlighted the areas of claddings, hardware and flashings. Claddings had a high number of associated problems, in particular galvanised steel and aluminium. Aluminium is often specified as a cladding material for aggressive environments when galvanised steel is not considered suitable. This usage of aluminium in the more aggressive environments may account for the number of reported problems with aluminium.

BRANZ has published information regarding the protection of galvanised steel and steel (Building Information Bulletins 214, 253). Other information has been published by various organisations about the performance of painted and unpainted steel and galvanised steel in New Zealand (HERA, 1986 and SANZ, 1987). Surface preparation and coating system information is also available through paint manufacturers' technical data sheets.

It would appear that galvanised steel and steel problems are still occurring despite widespread research in these areas and the general availability of information. This implies that: the information is not reaching the people who require it; the information is not in a usable form; or the importance of the information is not stressed.

The results from section C of the questionnaire (examining the expected performance of metals and coatings) indicate a general agreement amongst respondents. The metal examples used by respondents reflected the results from section A (metal problems). Galvanised steel claddings were a large proportion of the examples, the rest comprised aluminium joinery, structural steel, galvanised steel flashings and various hardware types. The coating types reflected the results from section B (coating problems). A large proportion of the examples were exterior paint on galvanised steel, the rest comprised factory-coated galvanised steel and powdercoated aluminium.

Metals tended to be seen as strictly functional and coatings were viewed as having a more decorative function. Metals required repairing when problems developed, whereas coatings needed to be repaired when a problem was at an early stage (see Figure 5). A problem for a metal was seen to occur when the metal function was impaired and a problem for a coating was seen to occur when the appearance was impaired. These differences in expectations between a coating and a metal may reflect the costs of metal repair compared to the costs of coating repair. Or they may reflect the perceived function of a metal and a coating. A coating may be regarded as primarily aesthetic rather than protective.

The expected life of a metal varied widely from 5 to 25+ years. This low expectancy may be due to past poor performance of metals or a general

attitude that a metal should fail before remedial action is taken, either because it is more economic to replace rather than repair, or information on maintenance is not available.

The expected life for a coating before requiring maintenance was 5 to 10 years. Assumptions of coating lifetimes have been made by Jansen (1984). Decorative coatings can be expected to last for 5 years, heavy duty coatings can be expected to last for 8 years and high build coatings can be expected to last for 10-13 years. Powdercoating and anodising can be expected to last for 12-15 years (Brown, 1987) and coil coatings can be expected to last for 15-20 years (Cordner and Whitney, 1984). The range 5 to 10 years appears rather conservative for some of the industrial and factory-applied coatings and could be due to the use of these coatings in severe environments with a corresponding decrease in life.

CONCLUSIONS

Galvanised steel cladding, aluminium cladding, exterior paint on steel and on galvanised steel were all associated with a number of problems. These materials have been researched in the past and information on their performance in New Zealand is available. An awareness needs to be fostered in the building industry of the availability and usefulness of the information.

The other area with a high proportion of problems reported was anodised aluminium joinery. This would indicate that the performance of aluminium joinery in the New Zealand environment requires further investigation.

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APPENDIX - Survey Design and Analysis

INTRODUCTION

A mail questionnaire was chosen to carry out the survey. There are advantages and disadvantages of using mail questionnaires (Moser and Kalton, 1972). The advantages are the savings in time and money as a result of not having to individually interview all respondents. Mail questionnaires are useful if questions are long and answers require a lot of thought from respondents (either remembering past instances or technically complex questions), or a lot of information is required. The disadvantages of mail questionnaires are that questions need to be simple or respondents need to know the topic as explanations of questions are not practical. The answer given is final, respondents can not be asked for supplementary or deeper information on a question. A further problem is that of non-response (Oppenheim, 1970). This may be quite high with mail questionnaires. Non-respondents are not always a random portion of the sample, and their characteristics may need to be identified as these may bias the results.

The questionnaire was able to minimise these disadvantages. Respondents were selected from the building industry and had some knowledge of metals, coatings or both. The tabular form of the questions helped make the questions clear and avoided ambiguous answers. There was room provided for comments and further information.

A pilot survey was sent out to a small sample of the respondents. This was used to identify any potential problems with the questionnaire so that they could be avoided.

ANALYSIS

For each metal the degree of experience and number of problems were collated for each building component. Each metal was expressed as a percentage of the total metals. Those metals that were deemed to be significant (the upper quartile was used as a guide) were further analysed. For these metals, the degree of experience, and of problems were plotted.

A similar analysis was performed for coated metals and for building components. The results to be analysed further were selected using the same criteria.

The results from section C (the section dealing with opinions and expectations of the respondents) were summarised as bar charts. The answers for the metal and coating examples were then plotted separately.

DISCUSSION

QUESTIONNAIRE

When the results were analysed, it became apparent that the wording of some questions was slightly ambiguous. Two problems with the questionnaire were identified. These were the interpretation of the terms claddings and roofings in section A, and of anodised aluminium in sections A (the section dealing with metallic problems) and B (the section dealing with coating problems).

Claddings and roofing were presented as two different components of the building, but the term cladding was used interchangeably with roofing, some respondents would use one term and not the other, other respondents duplicated their answer under the two categories. To overcome this disparity the results were combined in one cladding category.

Anodised aluminium was listed as a metal in section A of the questionnaire. Some respondents listed anodising as an additional coating in section B. These results were combined with the section A anodised aluminium results.

Bias

It is possible to introduce bias in the results at various stages of the survey process: at the design stage; when selecting respondents; or during analysis of results (Moser and Kalton, 1972).

Respondents' categories with a high number of replies were engineers, researchers and consultants. Those categories where no replies were received were building inspectors, plumbers/roofers and property managers. Engineers, consultants, building inspectors and property managers have experience with a range of situations where metals are used, and so high or low responses from these categories would not be expected to cause bias. Plumbers/roofers could be expected to have experience with galvanised steel and aluminium claddings and flashings and possibly lead flashings. A higher response from this category may affect the relative importance of problems with aluminium claddings and flashings (lead or otherwise) but would be unlikely to affect the relative importance of galvanised steel cladding problems.

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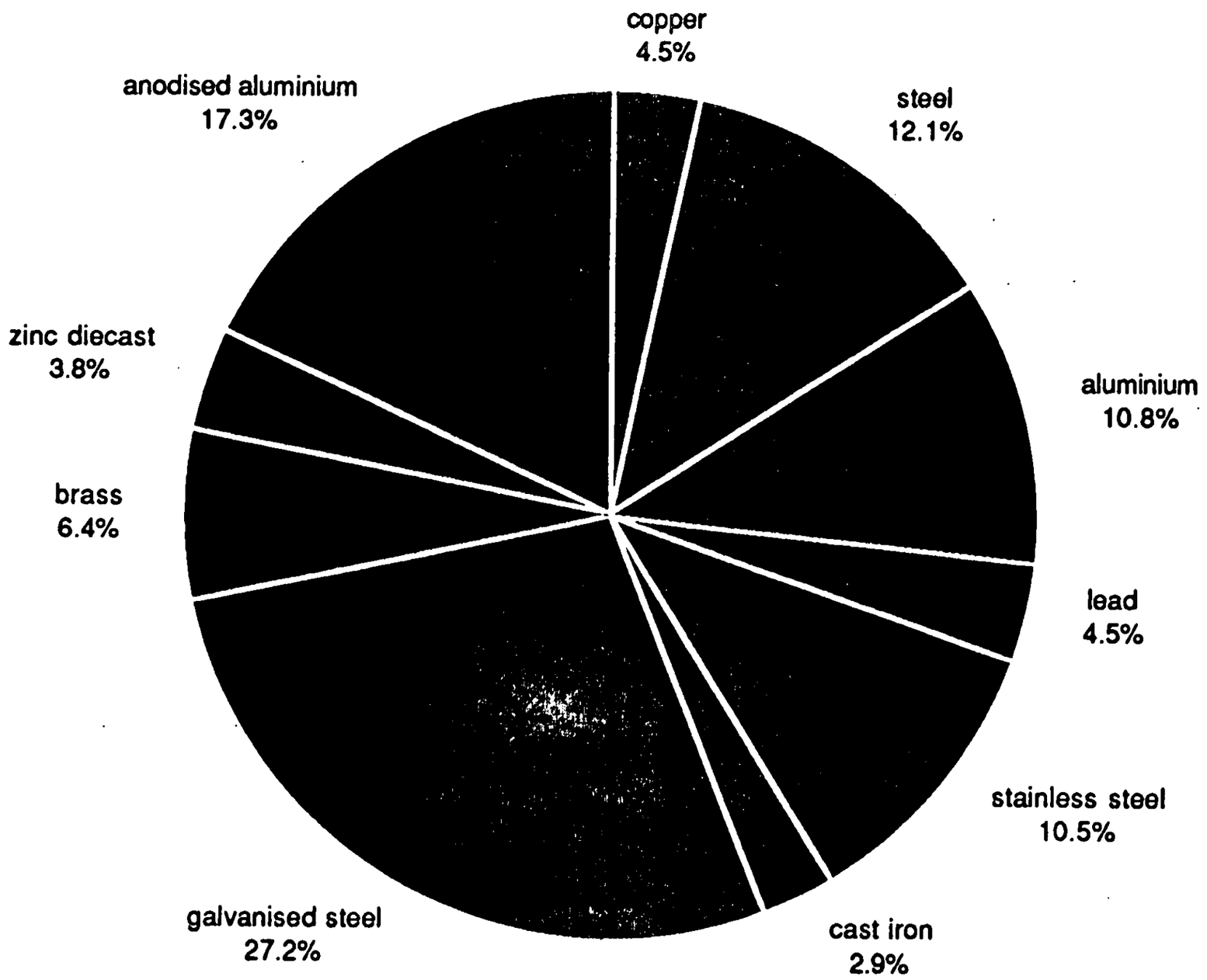

Figure 1: Degree of experience with metals

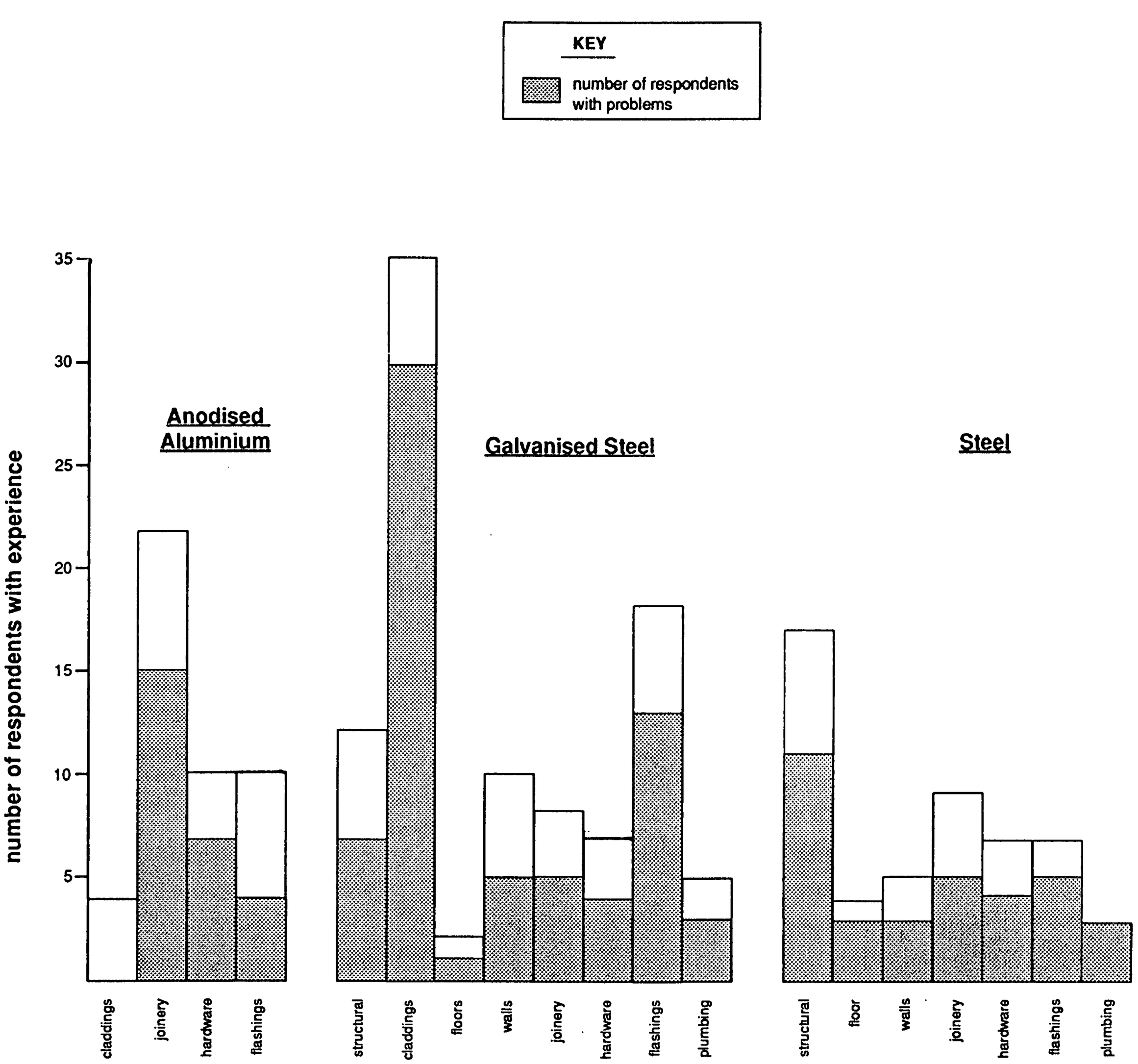

Figure 2: Number of respondents claiming experience and problems with anodised aluminium, galvanised steel and steel

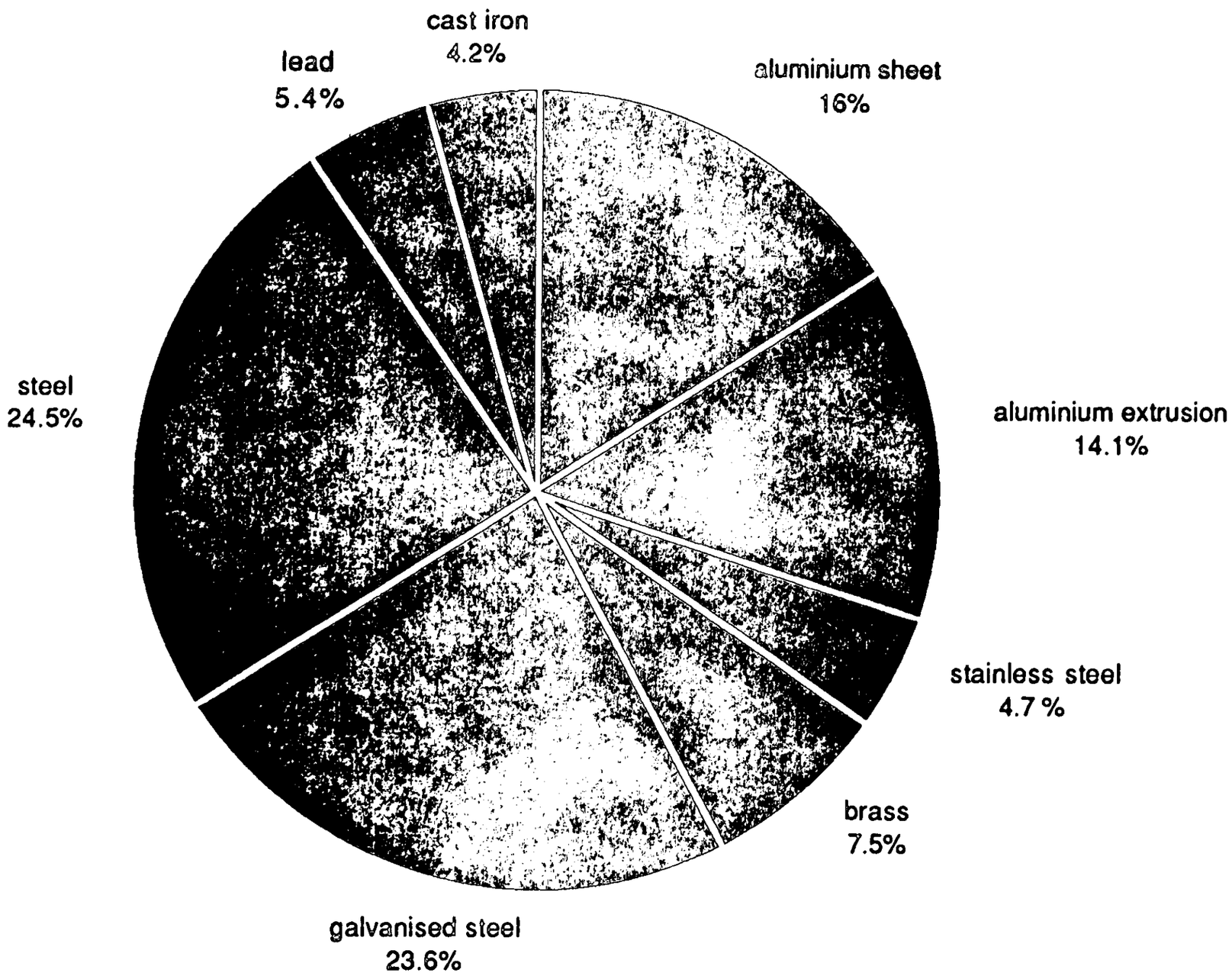

Figure 3: Degree of experience with coated metals

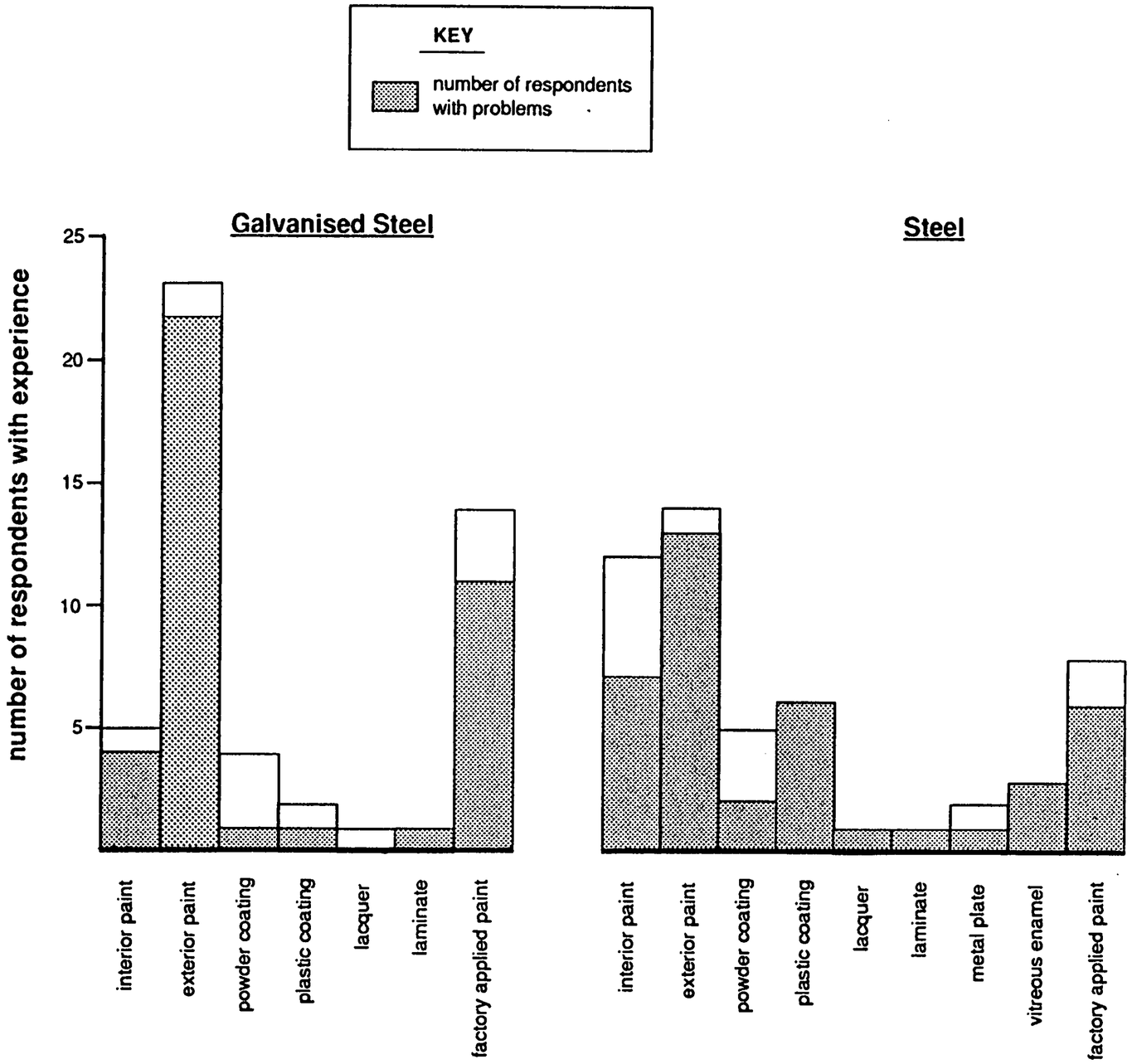

Figure 4: Numbers of respondents claiming experience and problems with coatings on galvanised steel and steel

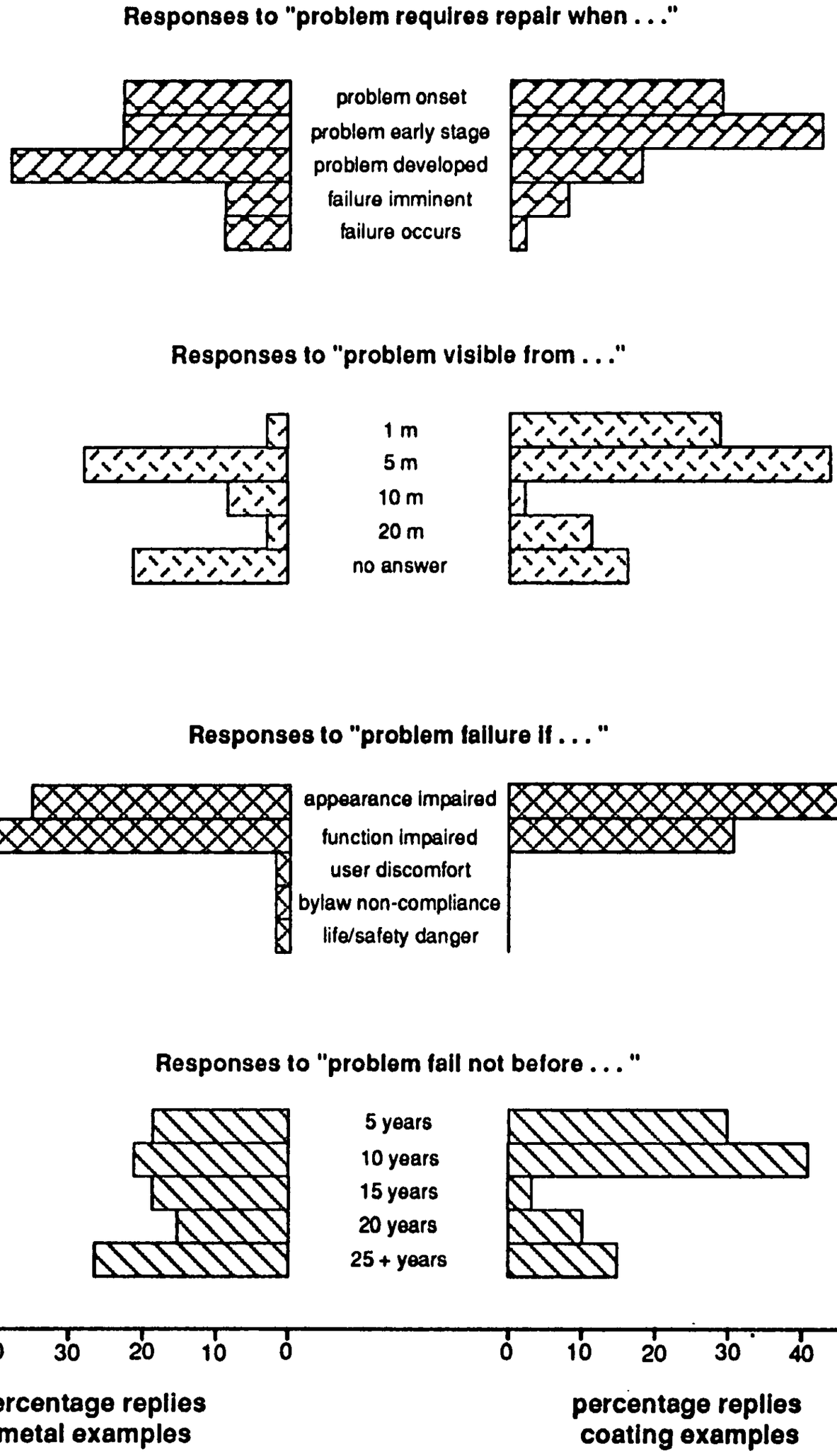

Figure 5: Respondents' performance expectations

Survey of metal problems in the building industry.

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ISSN 0113 - 3675