Design and Infrastructure – Sector Review of Attitudes

Publica

Contents

Foreword

The National Infrastructure Commission set up the Design Task Force to advise on how best to ensure quality design in future major infrastructure. We have reviewed experience of infrastructure design, interrogated infrastructure professionals, and looked at examples from the UK and beyond. Our work has been supported by three important pieces of research, including this study of sector attitudes to design and infrastructure. Thank you to everyone who contributed.

The results of this study confirm the demand for better design in the way we plan and deliver the nation's infrastructure. The barriers we identify are significant but they are far from insurmountable. As infrastructure investment becomes a national priority so the benefits of quality design become ever more important.

Our recommendations for improving the design of major new infrastructure are included in the National Infrastructure Assessment. They include establishing a small, agile, independent National Infrastructure Design Group to act as a design champion and prepare new national infrastructure design principles. We are also asking for all national infrastructure projects to include a design champion in their senior governance and for each to be subject to review and consideration by an independent Design Panel.

May I thank all those who have contributed to our work and the members of the Design Task Force, Lucy Musgrave, Isabel Dedring, Hanif Kara and our advisor Tony Burton.

Professor Sadie Morgan
Commissioner, National Infrastructure Commission

1   Introduction

The National Infrastructure Commission established a Design Task Force to advise on how to put design at the heart of the country's future infrastructure planning and ensure quality design in future major infrastructure.

The Design Task Force has set out an approach to design that goes beyond the aesthetics of a project to include:

- Thinking creatively about the processes involved in providing infrastructure
- Problem-solving from the outset of a project
- Making infrastructure human-scale and user friendly
- Enhancing the environment and improving quality of life for local people and nearby communities

Publica was commissioned to undertake a targeted sector review of the current attitudes and perceptions towards design in infrastructure planning and delivery. The purpose of this research is to identify existing barriers as well as opportunities for new approaches to the design of infrastructure projects, particularly those that employ design as a process for problem-solving. The review was conducted in June 2018.

Two additional research studies have been undertaken concurrent to this one: scoping and development of an approach to the first design principles for national infrastructure (also conducted by Publica); and providing a portfolio of examples of good infrastructure design. Together these provide a three-part evidence base for the Design Task Force's recommendations to the National Infrastructure Commission included in the National Infrastructure Assessment.

2   Research Approach and Methodology

The findings from this report are the result of a robust research methodology that involved sourcing and analysing both quantitative and qualitative findings from the target audience. A series of one-to-one interviews were conducted alongside the dissemination of an online survey questionnaire and a workshop.

The target audience

The Design Task Force defined the target audience for this research as non-design professionals within the infrastructure sector, namely chairs, CEOs, programme managers, and engineers.

Care was taken to ensure that the target audience included representation from each of the infrastructure types identified by the National Infrastructure Commission (NIC): transport, digital communications, energy, waste and wastewater, flood management and solid waste infrastructure.

One-to-one interviews

Publica conducted 13 one-to-one interviews with a set of key stakeholders within the infrastructure sector, each lasting approximately 30 mins. The interviews were semi-structured and aimed to access responses that would provide deep insight and understanding of issues and barriers identified by the Design Task Force.

A long-list of over 160 potential interviewees was developed and refined into a short list. The list included a range of mostly non-design professionals in infrastructure (chairs/CEOs, programme managers, young professionals) who will be critical to an uplift in design quality in infrastructure planning. It also included members of the National Infrastructure Commission's Young Professionals Panel. A small selection of design professionals who are deeply embedded in the process of delivering infrastructure projects were also selected for interview for their perspective on current barriers and challenges. The final list (see appendix) was selected to include a range of infrastructure types, geographies, levels of experience and project roles.

2   Research Approach and Methodology

Survey Questionnaire

The survey was used to access quantitative responses in order to gauge the scale of key issues and access a wider range of views.

Publica developed a concise and targeted survey questionnaire and compiled a broad survey audience of non-design professionals in infrastructure. The questionnaire (see appendix) included a combination of closed-ended, multiple choice and likert-type scale questions. The survey ends with three open-ended questions: the first asked respondents to describe barriers to improvements in infrastructure design; the second asked them to name what they thought was the best designed infrastructure project; and the third allowed respondents to add any additional comments.

Publica administered the survey to the target audience via SurveyMonkey web and social media links. The survey was disseminated through the networks of a number of infrastructure sector associations and businesses, listed in the attached appendix. Organisations were asked to share the survey via their direct communications with their membership and employees, and to broadcast the survey via their social media channels.

The survey, which ran for a ten day duration, received 56 responses, with the majority of respondents leaving detailed comments. These findings have been included in our qualitative analysis. Survey responses came from a broad mix of professionals working on infrastructure projects across the UK.

Workshop

Additionally, on 19 June 2018, Publica hosted a two-hour workshop with six attendees, which included representatives from the NIC Young Professionals Panel and design professionals working in the infrastructure sector. This workshop was run as part of a concurrent research study on developing design principles for infrastructure projects, also commissioned by the NIC.

2   Research Approach and Methodology

The workshop revealed key barriers and opportunities for improvements to infrastructure design, and the insights from these discussions have been included in the qualitative findings of this research study.

3   Findings

3.1 Existing Barriers

The Design Task Force's early analysis identified four perceived barriers to quality infrastructure design:

- A lack of champions in the way projects are governed
- A lacuna in design knowledge among those running national infrastructure projects
- A failure to embed design in the day to day working practices of those responsible for programme delivery
- A deep seated perception that good design adds cost and poses risk to delivering projects on time and on budget

In addition to investigating the barriers listed above, this research study has identified five additional barriers:

- Multiple conflicting perspectives over the role of design in infrastructure and who should deliver it
- Cultural barriers between disciplines
- A lack of infrastructure delivery experience among design teams
- Poor project briefs and short-sighted planning
- Inflexible planning policies

3.1 Existing Barriers

Results from question 12: infrastructure planning would benefit from more design expertise

- Strongly Agree 77%
- Agree 12%
- Neutral 9%
- Disagree 2%
- Strongly Disagree 0%
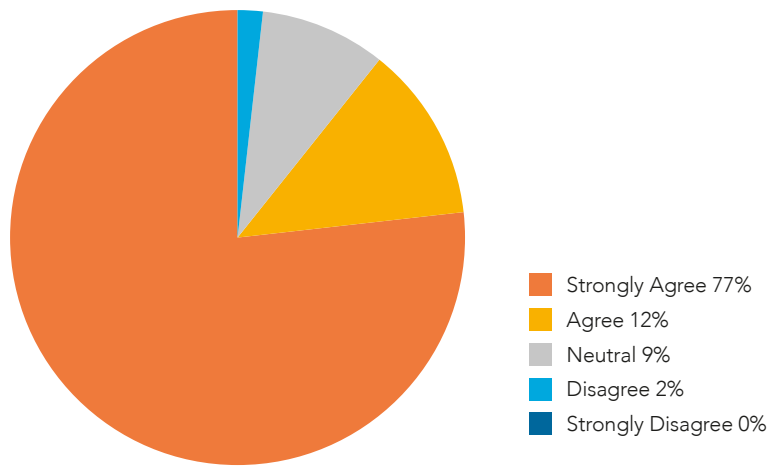
Results from question 13: each infrastructure project needs a design champion at a senior level

- Strongly Agree 82%
- Agree 9%
- Neutral 9%
- Disagree 0%
- Strongly Disagree 0%
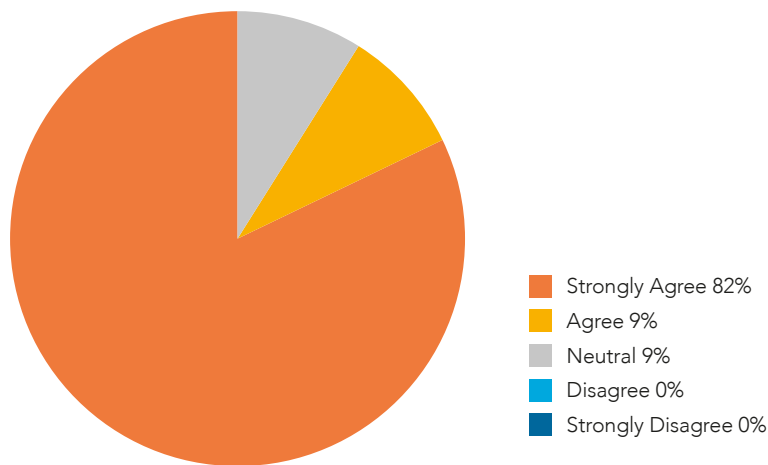
3.1 Existing Barriers

During the interview process there were numerous occasions when respondents views aligned with the the Design Task Force's analysis and defined barriers.

Both the survey respondents and the interviewees reported that a major barrier to raising the quality of design in infrastructure was a lack of champions in the way that projects are governed. They cited a need for strong leadership in terms of design prioritisation and in managing the process of developing a project on the basis of the priorities and outcomes outlined in the brief.

Infrastructure and engineering design teams are vast and complex, described by one interviewee as 'huge and clunky', and require a huge amount of coordination. In engineering-led projects, championing broader design benefits for a project within the challenges and constraints of a massive, complex and often bureaucratic process has proven to be extremely difficult.

Without strong leadership, it is also difficult to ensure that a very large project team understands their individual roles and remains motivated to push the project forward, particularly for projects that typically last many years.

Design is a management process as well as a creative art. Please let's talk about both of those things being important.

— Andrew Wolstenholme, former Chief Executive of Crossrail and civil engineer

Another of the interviewees spoke about the challenges they had faced with a design panel who they felt had pursued design as its own end and described how they had struggled ever since to reconcile these two positions. They described feeling that they were doing design for design's sake, instead of seeing it as an enabler.

From another perspective people feel like design is being done to them. So instead of being an integral part of enabling solutions, enabling smart infrastructure, enabling planning consent, enabling our aspirations, it's been something that's

3.1 Existing Barriers

been bolted on as an add-on, and that's something that's flawed, we've found ourselves with quite a lot of tensions.

Another interviewee, Emma Smailes, Operations Manager at the Environment Agency spoke more expansively about the current restrictions to embedding design into projects:

One of the things that would be interesting, and I know that some of our policy makers are thinking about it at the moment so when we invest as the Environment Agency in our flood schemes, we invest in what is there now, so we protect what is existing, but we can't take into account growth, so our investments can't factor in an economic growth element. All we can do is protect what's there now, and its one of the things that would be quite useful for me, getting a broader design perspective across is being able to fund for growth. Knowing full well that by doing what we do, sometimes we can really regenerate an area and add some fantastic benefits.

— Emma Smailes, Operations Manager, Environment Agency

The research results also reinforce the Design Task Force's analysis that there is a deep seated perception that good design adds cost and poses risk to delivering projects on time and on budget. Additionally, it was revealed that there is a relationship between this perception and a commonly held fear among project managers that designers or design panels can add additional risk and complexity by actively promoting design.

Those actively promoting design can be seen as unduly raising the expectations of planning authorities and, by doing so, risking additions to the cost or programme of a project. This fear is driven by the widely shared view that changes to the design of an infrastructure asset in the advanced stages of its development can cause huge instability to the business case and potential funding of that asset.

If you want to make a statement with certain assets, in terms of you want to call iconic by design, and you want to invest, then fine, but you don't have to do that. If you've got the Design Panels off talking to local authorities about what the art of an

3.1 Existing Barriers

iconic design structure could look like, you set an expectation that a project manager won't thank you for if you can't afford it.

— Mark Thurston, Chief Executive of HS2 and an electrical engineer

Cavendish Elithorn, Director of Major Rail Project Development at the Department for Transport, identified the key barrier for improving infrastructure design as 'the belief that design is about being iconic,' which reflects a widely-cited perception that architects and designers tend to produce impractical or overly ambitious designs that are largely symbolic and expensive.

Answers from the survey questionnaire also revealed a perception that design consultants can fail to consider constructability in their designs, leading to a late re-working of their proposals.

One of the interviewees cited a frustrating situation where the design options for a badly needed infrastructure asset produced by the commissioned design team were too expensive to deliver, and that additional money was subsequently spent to design alternative options.

On the other hand, survey respondents also reported that project managers lack direct engagement with design challenges, leading to a lack of understanding and disinterest of strategic issues around the design of a project. Some project managers have reportedly attempted to curb the project team's engagement with the planning authority, limiting consultation with key stakeholders. This finding also points to the Design Task Force's early analysis which identifies a failure to embed design in the day to day working practices of those responsible for programme delivery.

Some interviewees reported a resistance or even hostility to change and innovation by some project managers in favour of traditionally accepted practices. This was largely cited as being due to a fear over the risks and effects of these changes on the budget and programme of projects. It is also linked to a perception cited by survey respondents that design in the

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architectural sense is often perceived as a 'pretty add on' rather than essential and integral to the success of a project.

Through the research, an additional five barriers were identified by Publica as representing significant obstacles to the integration of design into infrastructure projects.

Multiple conflicting perspectives over the role of design in infrastructure and who should deliver it

The survey and the interview results show a broad agreement that design, of some form, is a fundamental aspect of creating an infrastructure asset. However, the responses from interviewees qualitative survey question reveal divergent opinions around the role of design in infrastructure, and as a result, who is best placed to deliver it.

When we define design, it is actually the specification to define the outcomes. Part of those outcomes are what do they look like, and what is the sense of place created by it? And those tend to be developed by architects. But let's not get trapped by saying design is architecture. Architecture is a hugely important part of it, but only one part of it.

— Andrew Wolstenholme, former Chief Executive of Crossrail and civil engineer

I would define the role and value of design in infrastructure projects as gathering various data forces, whether that limits the design or enhances the design, but collecting data from all kinds of places including the community and developing a plan using it. That data then feeds into what actually gets built.

— Joshua Dickerson, Associate at Deetu and member of the NIC Young Professionals Panel

The survey asked respondents to select their top choice for how they would define the role of design in infrastructure from the approach set out by the Design Task Force.

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Results from question 5: how would you define the role of design in infrastructure?

Answer choices	Responses	
Thinking creatively about the processes involved in providing infrastructure	14.29%	8
Problem-solving from the outset of a project	37.50%	21
Making infrastructure human-scale and user friendly	8.93%	5
Improving the aesthetics of a project	0.00%	0
Enhancing the environment	3.57%	2
Improving the quality of life for local people and nearby communities	28.57%	16
None of the above	7.14%	4
Total respondents		**56**

3.1 Existing Barriers

The majority of survey respondents selected 'problem-solving from the outset of a project' as the primary role of design in infrastructure, followed by 'improving the quality of life for local people and nearby communities.' Notably, no respondents selected 'improving the aesthetics of a project' as their definition of the role of design in infrastructure.

The survey findings indicate a broad agreement with the Design Task Force's approach to design in infrastructure as having a wider role that goes beyond the aesthetics of a project. However, the interview findings provide evidence to suggest that survey respondents, and non-design professionals working across the infrastructure sector, tend to consider engineering as the most relevant articulation of design in infrastructure, above architecture, landscape or urban design.

Our study found that non-design professionals typically place emphasis on the fundamental role of 'technical' or engineering design in the creation of infrastructure assets. This definition of 'technical' design is understood as delivering a solution for achieving the primary function of an infrastructure asset within the codes, standards, restrictions and budgets that govern its creation. Many interviewees defined 'problem-solving at the outset of a project' as a form of technical design.

Design is such a broad word to use to sum up basically everything that comes about to create infrastructure, everything sort of pre-construction or even in construction is design, it's the planning of a project basically.

— Joshua Dickerson, Associate at Deetu and member of the NIC Young Professionals Panel

Furthermore, a number of non-design professional interviewees identified 'improving the quality of life for local people and nearby communities' as the inherent outcome of building any new infrastructure asset, as long as it is successful in its primary prescribed function (i.e. a train that gets people from A to B) rather than a design that delivers other social, cultural or spatial benefits, and that may require broader design expertise.

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The survey found that only two respondents selected 'enhancing the environment' as a primary role of design in infrastructure; and only five selected 'making infrastructure human-scale and user friendly.'

Traditionally we have focused on just the design of the infrastructure, and not the user's experience so much. It's really important, but it means the space in which the infrastructure sits or its wider urban integration can either get lost or forgotten. When looking at the costs and risks of delivering these massive projects, there may be a tendency to see the other scales of design as a luxury add on, the airy-fairy extra fancy bits. The engineering side will take precedent. That obviously is design but it depends what you mean by design.

— Esther Kurland, Head of Urban Design at Transport for London

Cultural barriers between disciplines

Multiple interviewees cited the cultural barriers between design professionals (particularly architects, landscape architects and urban designers) and non-design professionals (particularly financial modellers and project managers with engineering backgrounds). Reasons for this gap include differences in educational background, training, work experiences, priorities and even language choices that reportedly make it challenging for different disciplines to work together collaboratively or see the value of each others' work.

Interviewees cited a long-standing tension between an 'engineering design view' and an 'architectural design view' of infrastructure, two perceived views that are typically understood to be at odds with one another. Both design professionals and non-design professionals interviewed cited a lack of design training or full awareness of meaning or value of design by those working within delivery organisations.

People who are looking at business planning and business modelling, just by the function of the profession they've chosen, they probably have less interest in design and aesthetics than

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the designers. They probably don't even think about the value of it. They see the value of the bridge in that you can get across the river. The fact that the bridge also might have a value because it's beautiful or giving jobs to local people or that it will last 200 years rather than 20 years, they are all deeper questions that maybe financial modellers just don't ask. Those are the people making the decisions, and they have very very limited budgets..

— Ann Bentley, Chairman at Rider Levett Bucknall

A lack of infrastructure delivery experience among design teams

The survey results found that a lack of experience or technical expertise among design teams was seen as the biggest risk involved with incorporating design into infrastructure projects. When asked if infrastructure planning would benefit from more design expertise, 91% of survey respondents agreed that it would. Insight from the interviewees revealed that the fragmentation of design expertise across the infrastructure sector is a likely factor in this result.

Andrew Wolstenholme, former Chief Executive of Crossrail, cited a critical need for well-integrated teams of designers, who are able to work with both engineering and architecture priorities in mind, and who can draw all the skills of the project team and its complex challenges together. He said that three decades ago, architects may have been the lead consultants on projects from a holistic, ie, functional, creative and spatial point of view, but as projects have become increasingly complex, their role has increasingly become more fragmented or limited in scope.

Similarly, Ann Bentley, Chairman at Rider Levett Bucknall, said that three to four decades ago, deep expertise on the design of each type of infrastructure resided within the companies or departments delivering it, such as British Rail, the Department of Transport, or within water companies. That deep expertise has mainly been lost or transferred and the vast majority of that work has been moved to the private sector. While engineers and design teams within the private sector have a high degree of expertise, they tend to work on a wider range of projects, which

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she said typically makes it more difficult to maintain an understanding of current best practice within each infrastructure type.

There's a massive missed opportunity in feeding learning back into the process. Instead of citing the bad projects, citing the good projects and then building on those... I think that we actually got poorer than that in some areas, because of the fragmentation, I think we used to be better. I think the way that lessons learned get fed back into the process is very poor.

— Ann Bentley, Chairman at Rider Levett Bucknall

Harbinder Birdi, architect and partner at Hawkins Brown, said that there isn't enough design expertise in the UK industry in relation to the volume of infrastructure being built. While national infrastructure projects may receive more scrutiny and design expertise, projects that are smaller in scale are frequently overlooked. In some cases, projects are led by local authorities who lack design expertise or who are unfamiliar with cross-disciplinary working. Similar inconsistencies were noted by Ann Bentley:

The commissioning teams in the railway industry are actually quite varied. You've got some really good ones and you've got some that are quite immature in their experience, and it's not an immature industry. Even within a client body, you have hugely different levels of expertise. If the expertise in the client body is low then you'll get a rubbish brief, then you're always sort of fighting to an extent.

— Ann Bentley, Chairman at Rider Levett Bucknall

Esther Kurland, Head of Urban Design at Transport for London said that the industry lacks a deep understanding of how to ensure a piece of infrastructure relates to and integrates well with both its immediate and wider surroundings, and cited a failure in the sector to learn from past experiences, and a lack of demand for better outcomes from clients and politicians. She describes a political culture where politicians feel the pressure to make big decisions about delivering major infrastructure assets, without necessarily understanding the broader implications of

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spatial design or deliverability. Similarly, survey respondents noted instances where projects were politically-driven, rather than needs driven.

Dr. Colin Church, Chief Executive Officer of The Chartered Institution of Waste Management (CIWM) explains that often with highly specialised infrastructure assets, such as the energy from waste industry, the organisations responsible for financing the asset do not always have a full grasp of the technology. This lack of understanding also means that although they are making major decisions about the project brief, they are often not confident or experienced enough to know that they need additional design expertise.

Emma Smailes, Operations Manager at the Environment Agency, focused on flood protection, describes a current and severe lack of resource among civil engineers in the sector due to the 2008 recession driving many engineers into other professions:

Now we're back into boom again and we just don't seem to be able to hold a line within the engineering industry, we're just constantly steeped in famine, which really puts pressure on, and there's a real lack of graduates. We're the only agency building new reservoirs, and the age profile of people that we have who can do this stuff is well up into the 50s and 60s, so there just isn't that cohort coming through. So this means you tend to get quite traditional designs because the people you have got are just churning it out under great pressure.

— Emma Smailes, Operations Manager at the Environment Agency

Poor project briefs and short-sighted planning

A clear and consistent response from interviewees revealed the critical importance of a robust brief and long-term strategic planning to improving the quality of design in infrastructure. Survey respondents and interviewees noted narrow project briefs that relate only to the function of infrastructure and that fail to relate to the wider impact of the asset, with the limited

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scope reflecting limited feasibility stages, short project lead-ins and a rush to construction.

Interviewees also cited a tendency for clients to only look at initial building costs, rather than whole-life costing in making decisions about value that design could bring to a project. Survey respondents cited poor procurement processes cited by one respondent as 'going in cheap and picking up the pieces later.'

Procurement is messy - the people being dealt with during procurement aren't the end users of the project.

— Les Sparks, Expert Panel member at MADE and architect and town planner

Procurement is designed to be as auditable as possible, not for innovation and small practices.

— Martin Stockley, Member and Vice Chair of Highways England Design Review Panel and an engineer

Many interviewees said that it is precisely during the very early stages of infrastructure planning where it is most critical to invest time, energy and design expertise into determining the principles, outcomes and long-term vision for a project. They said these decisions must then be translated into detailed, clear and robust project briefs; one that considers the client's needs, the project constraints, and the potential benefits that could be achieved through the development of an infrastructure asset, over the course of its full lifecycle.

Whilst the cost of feasibility studies is relatively low compared to the overall scheme, clients facing heavy financial constraints are typically unlikely to invest more than the minimum, even when doing so would likely deliver long-term value during the construction and overall lifecycle of the infrastructure asset. Design consultants, who are often working to a tight budget during the feasibility stages, said they could do much more, but have no scope to do so. A number of interviewees emphasised a need to convince clients of the cost benefit of spending more time at the front end of a project.

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I think it's down to the costs and priorities of the project and the developer and the key stakeholder involved, it depends what their ambition is for the site. If it's their site to hold on to for the next 100 years or so then the design will probably be more important, but if they're going to just build it and sell it on as an asset, likely they will try to design it to be as cheap as possible, so anything extra they won't be interested in.

— Joshua Dickerson, Associate at Deetu and member of NIC's Young Professionals Panel

Interviewees reported that clients, particularly those who are developing an infrastructure asset with purely commercial motivations, tend to think of design primarily as a function of getting statutory and regulatory approvals. If the project brief does not protect key elements of the design by explicitly detailing that they cannot be removed for cost savings, then there is a strong likelihood that those design elements will be cut in the process of value engineering.

What often happens on these projects is that the clients will get one set of consultants to create a design for the project that's the one that gets permission. But then they'll instruct somebody else who's going to build it, and then the latter will often change the design in a way that is driven purely by cost savings, as they've been told to do.

— Angus Walker, solicitor at Bircham Dyson Bell LLP, specialising in infrastructure planning, and Board Chair of the National Infrastructure Planning Association

3.1 Existing Barriers

Inflexible planning policies

The system is constraining. Once you have your approval it's often very difficult to change the design or incorporate flexibility to adapt to change that might be needed, that might be happening in the adjacent communities that couldn't have been foreseen at the time. Often these projects roll on for a long time, but once you've got your consent if you need to make a change it's very very difficult to, and sometimes you might need to.

— Sheena Bell, Senior Associate and Landscape Architect at Gillespies

Interviewees cited a lack of flexibility in the planning system and processes for infrastructure planning as a key barrier for ensuring that the design of infrastructure projects reflects local needs over the course of its development or lifecycle. Once consent is granted, making changes to aspects of the design of a project is time consuming and can be disruptive to the progress of the project. Frustration over missed opportunities to provide greater community benefits over the course of a project were also attributed to the rigidity of the planning processes.
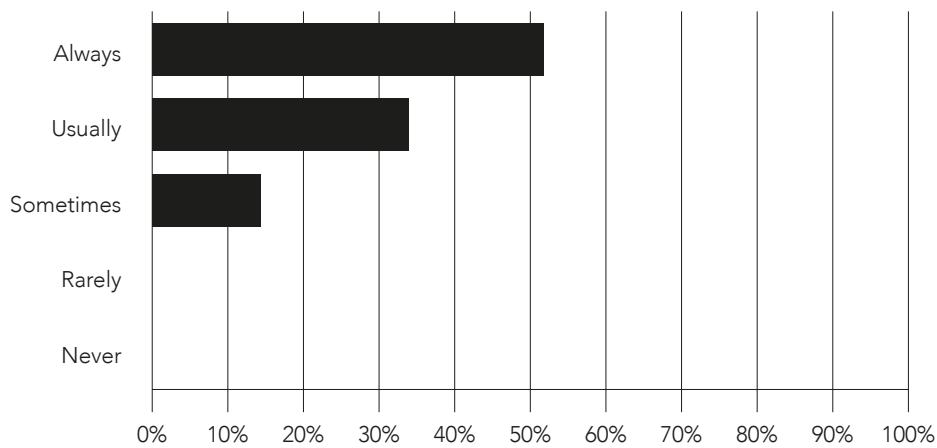
3   Findings

3.2 Opportunities for New Approaches

Results from question 6: do you think design can improve the processes involved in infrastructure planning?
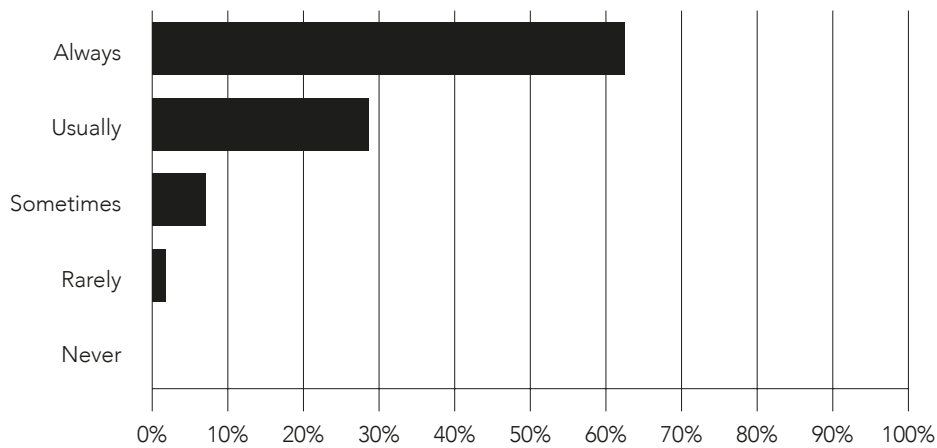
Results from question 7: do you think design can be used to solve problems within infrastructure planning?

3.2 Opportunities for New Approaches

The study identifies seven opportunities for new approaches that respond to the challenges outlined:

- Expand the definition of design to include designing for the full lifecycle
- Set holistic design visions and principles based on clear outcomes and a long-term view
- Appoint design panels and/or senior design champions
- Learn from best practice across the sector
- Make design an integral part of enabling solutions
- Build greater flexibility into the infrastructure planning consent system and infrastructure planning processes
- Increase trust and respect across disciplines

Expand the definition of design to include designing for the full lifecycle

Interviewees identified a need for design to holistically address how an infrastructure asset will be managed and maintained over its lifecycle as a fundamental part of delivering design with a lasting value. Far too often, design only addresses delivering the cheapest technical solution, rather than looking at the whole life of the asset, and its ultimate users.

This definition could also be extended to include the end of life or end of use of an infrastructure asset, since at some point all infrastructure has to be taken apart or replaced. Addressing the 'end of life' of an infrastructure asset in the design process could provide opportunities to reuse or retrofit portions of assets as needs or technologies evolve.

Set holistic design visions and principles based on clear outcomes and a long-term view

General feedback that has been gathered in this study demonstrates that the importance of setting out the objectives and outcomes in the early stages of the project cannot be overestimated. Significant work could be done to help a full range of clients - from water, telecom and rail companies to local

3.2 Opportunities for New Approaches

authorities - to strategically consider the additional outcomes and benefits that they could achieve through their investment and the legacy of projects.

Interviewees suggested opportunities to think beyond the 'red line' of the site in the early stages of a project, to consider the wider benefits and impacts that the project could deliver both immediately and upon conclusion of its life cycle. Many also cited the importance of framing the objectives or outcomes of a project within a long-term view or vision that is articulated through design principles.

What the architects bring is the long-term view. On Crossrail, the only one still standing is the architect. Other consultancies don't tend to do that. The architects, they doggedly hang on all the way through. They don't really want someone else to change their design.

— Harbinder Birdi, Partner at Hawkins Brown, projects include Thames Tideway and three new stations in central London for Crossrail

Harry Armstrong, Head of Technology Futures at Nesta, suggests that there is a further opportunity to use design to think more strategically and expansively about the issues that infrastructure typically addresses with a direct solution (ie. building a new road to meet the demand of increased traffic). He said that design thinking could be applied to these challenges more holistically to find ways to address the cause of the issue (ie. reducing traffic volume and thereby eliminating the need for new roads). Applying broader, strategic design thinking to major infrastructure projects could help to better address future scenarios and new technologies.

Appoint design panels and/or senior design champions

As previously cited, 91% of survey respondents agreed that infrastructure projects would benefit from having a design champion at a senior level.

3.2 Opportunities for New Approaches

The majority of interviewees agreed that there would be a benefit to appointing a design champion at a senior level or a design panel, if that person or group of people has enough involvement and continuity with the project that they are well aware of the project nuances over the entire course of its development.

Interviewees stressed that it is critical that the design champion or design panel is involved early in the project when it's still possible to make an impact; as in many cases a change to the design at a later stage could have such major implications that it would not be tolerated by the project manager and project team. They also stressed the importance of that design panel or champion being meaningfully embedded in the development process, in a way that is directly connected to the governance and structure of a project and with a clear understanding of the needs of the client and stakeholders.

You get the right experience and the right thinking and the right discussions with the right people at the right time like we've got with these Phase 2 stations, where we have more time, and it's much much earlier in its development. You know we're developing masterplans for stations in the surrounding areas that will transform lives in those cities. And the HS2 station will almost become incidental.

— Mark Thurston, Chief Executive of HS2 and an electrical engineer

Learn from best practice across the sector

Interviewees cited examples of infrastructure projects or agencies that are working to improve commissioning practices, extend early design and feasibility stages, and measure the impact of their projects on communities. Opportunities could be taken to share the best practice principles developed within these projects and agencies to help inform principles for application across the sector.

Interviewees described how efforts by the government to improve the quality of commissioning by their agencies, such as

3.2 Opportunities for New Approaches

Highways England, have made a significant impact on design quality.

In addition, certain infrastructure types, such as nuclear energy and solid waste management, tend to have a higher quality of commissioning when it comes to procuring design expertise. This is because these infrastructure types often use design as a way to improve the acceptability of projects that would likely otherwise receive significant opposition from local communities. Good design has proven to be a valuable mitigation tool in gaining the support of communities and planning authorities by providing positive social and spatial outcomes.

Infrastructure types that face strong opposition to their development have a stronger tendency to invest in an early, strategic design process, that includes the involvement of architects, landscape architects and other design consultants to review design options, test sites and for projects to undergoing stakeholder consultation before planning processes begin and moving into further project stages. Commensurately, it was also noted that on projects where there was less objection to the development, the investment in design was likely to be much lower.

The nuclear industry is extremely interested in the impact on local communities as you can probably imagine because of what they're building. Strangely enough, they've spent enormous amounts of time looking at that sort of thing. They know they're going to face lots of local opposition, so they spend lots of time trying to build local support, and measuring the impact. In the nuclear sector it's the highest I've come across.

— Ann Bentley, Chairman at Rider Levett Bucknall

Make design an integral part of enabling solutions

In order to overcome perceptions that quality design in infrastructure is about being 'iconic' or that it adds cost and poses a risk to delivering projects on time and budget, design has to be seen as integral part of the project development process. This includes ensuring that design proposals help to enable planning consent; and that design work at each stage of

3.2 Opportunities for New Approaches

a project responds to the hierarchy of outcomes set out in the project brief; and that design solutions demonstrate economic and social value, if not immediately, then over the long-term.

Are designers enabling this design to be built easily, safely, with health in mind, can it be manufactured off site? Of course it still has to look good, but how is the design process itself going to provide the economic case for building this thing?

— Andrew Wolstenholme, former Chief Executive of Crossrail and civil engineer

Interviewees and survey respondents suggest that this could be facilitated in part by designers embracing new digital technologies that would help enable smart infrastructure. These technologies could aid in simplifying and streamlining the complex process of delivering infrastructure assets, as well as dramatically improving the operation, maintenance and use of new and existing assets. Being open to adopting and working with new technologies could play a significant role in maintaining quality design as the infrastructure sector evolves.

New digital communications tools are also providing an opportunity for designers to better consult and engage with local and neighbouring communities. Josh Dickerson from NIC's Young Professionals Panel and Associate at Deetu, a data and technology development hub, cited the need for better communication in national infrastructure projects between infrastructure teams, planning teams and the public. He suggests the possible use of branding and specialised communication teams to improve the quality of this dialogue, as well as the introduction of new technologies, such as interactive or virtual reality websites that that allow people to better understand a scheme and give them the opportunity provide live feedback.

Build greater flexibility into the infrastructure planning consent system and infrastructure planning processes

The opportunity to make adjustments or enhancements to a design at later stages of a project, often required to respond to

3.2 Opportunities for New Approaches

change in local or project circumstances, given the extremely long lead times for infrastructure projects, could be made easier by building greater flexibility into the planning consent system. This could help expedite the process of design development and reduce the risks and fear of impacts associated with change.

Sheena Bell, Associate at Gillespies and a landscape architect working on two sites for the Thames Tideway Tunnel project explained that the consent framework on that project was structured in a way that allowed the designers to revisit the design post-planning. This flexibility allowed the designers to increase the quality of design at those sites in the later phases as the project progressed, without causing unexpected disruptions or delays to the programme.

Increase trust and respect across disciplines

Interviewees, from both design and non-design professional backgrounds, acknowledged that the quality of the design of infrastructure would be improved if everyone involved in the process worked to overcome cultural barriers by showing more respect for other disciplines.

Interviewees cited approaches to overcome cultural barriers such as trying to understand the pressures faced by the other professions and disciplines and finding approaches to communication that aid in building trust and demonstrate a sense of common purpose.

All people in the design process should respect each other a little bit more. When you get this right, we are world class at this stuff. We should put the flag high up on the poll. I'm hugely proud that I've worked with Arup because they're world-class engineers, and I'm hugely proud that I've worked with Fosters and Rogers and Hopkins because they can't do it without us, and we can't do it without them.

— Andrew Wolstenholme, former Chief Executive of Crossrail and civil engineer

3.2 Opportunities for New Approaches

Quantity surveyors abhor change, change is money. And it's about knowing, this time you need to have the conversation because this time it'll make the project better. So it comes with a level of trust as well, trust for each other.

— Harbinder Birdi, partner at Hawkins Brown, projects include Thames Tideway and three new stations in central London for Crossrail

There should be optimism about the opportunities for future collaboration in design. The survey asked respondents to identify what they felt was the best-designed infrastructure project and responses covered many significant projects renowned for their design, including Crossrail and HS2. Respondents considered contributing factors that were wide-ranging and covered aspects such as user experience; progressive and sustainable design techniques and how a project team with a committed attitude leads to successful project delivery.

Selected responses from question 15: in your opinion, what is the best designed infrastructure project and why?

- Crossrail (cited by 6 of 56 respondents)
- HS1
- Hong Kong MTR
- Jubilee line extension & Hungerford bridge
- London Bridge Station *the works recently completed at London Bridge are both architecturally striking and also create a really effective use of space and place for people to come to and pass through. The also enhance the local built environment and will act as a regeneration catalyst in the area*
- Norwegian hydro power project, 2016 - *entirely paperless,* Oslo terminal 2, 2017 - *entirely model (not document/drawing) based*
- The Dryline, New York City. City *flood protection infrastructure*
- Paddington Bridge Project *stands out best and received many accolades including the 2006 BCIA top award. This was because it integrated design ingenuity with an adventurous approach to construction that significantly reduced the disruption to the travelling public. It was made possible only by the whole project team "buying-in" to the concept from inception to completion and all parties participating in a well planned and managed process*

4   Conclusions

This research study confirms the Design Task Force's early analysis of the key barriers to improving the quality of infrastructure design, and expands on each of these barriers through identifying related challenges that provide a deeper insight into these issues across the sector. The study also suggests a number of opportunities for new approaches that relate to the barriers that have been identified.

While this research reveals significant cultural barriers between design professionals and non-design professionals, it also illustrates clear overlaps in values and priorities that demonstrate opportunities to establish a common ground between disciplines and evidence for improvements to the process of delivering well-designed infrastructure. Almost all of those surveyed and interviewed describe the critical role of design in the process of developing infrastructure, particularly at the early phases of a project.

Many interviewees cited situations in which they have undergone cross-disciplinary work that has resulted in highly successful projects. In each case, they acknowledge that with the right team, productive collaboration is possible and has led to a higher quality of design.

Appendix

Survey Questionnaire Results

Q1 Your job title (optional)

Job title
Assistant Engineer
Associate
Bid Manager
Bridge Engineer
CEO
Chief Engineer
Civil Engineer
Civil Engineer
Civil Engineer
Construction CRe
Consultant
Control & Instrumentation Engineer
Design Manager
Design Project Manager
Director
Electrical Engineer
Electrical Engineer
Energy Storage Performance Analyst
Energy Storage Project Manager
Engineer
Engineer
Graduate Engineer
Graduate Engineer
Graduate Engineer
Group Manager (Civil & Rail Engineering)
Independent Consultant
Independent Civil Engineering Consultant
Information and Process Consultant
Lecturer
Major Programme Director
Major Projects Director
Manager of Resilience
Managing Director
O&M Solar Planner
Open-Ended Response

Survey Questionnaire Results

Job title
Owner
Principal Engineer
Principal urban design
Programme Director
Programme Manager
Project Manager
Project Manager
Railway Civil Engineer
Retired
Retired
Retired Infrastructure designer
Senior Civil Structural Design Engineer
Senior Engineer
Senior Planner
Senior Project Manager
Systems Engineer
Technical Director
Town planner
Transport planner
Tunnelling Consultant

Survey Questionnaire Results

Q2 Your organisation (optional)

Organisaton
Aec3 and buildingSMART
Anglian Water
Arcadis
Atkins
Balfour Beatty
Bridgetrack consultancy
Cass Hayward LLP
Colas Rail
Commercial Partnership (UK) Ltd., The
Costain
Costain
David Philpott Ltd
DS Engimneering Consultants Ltd
Frankham
Hounslow Chamber of Commerce
Isambard Projects Ltd
Keystone Tunnelling Ltd
Knight Architects
Laing O'Rourke
Laing O'Rourke Construction Ltd
Murtonrail Limited
Network Rail
North Yorkshire moors Railway
pilbrow and partners
Renewable Energy Systems Ltd
Renewable Energy Systems Ltd
Renewable Energy Systems ltd.
RES
RES
RES
RES
RES Ltd
RES Ltd
Retired
SNC-Lavalin Atkins

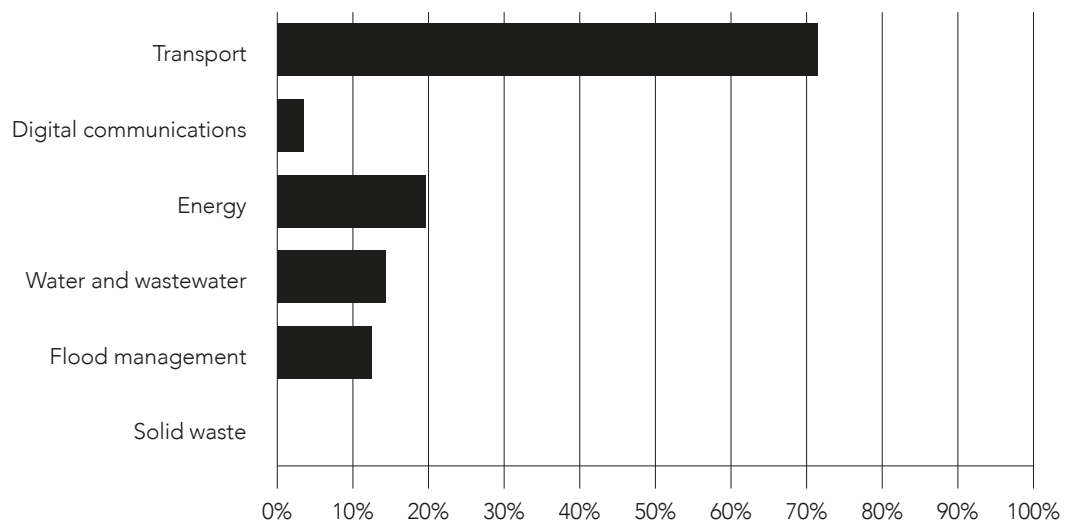| Organisaton |
| --- |
| The New Railway Consultation Service |
| Transport for London |
| Transport for London |
| University of Nottingham |
| Volkerfitzpatrick |
| Wedderburn Transport Planning |
| WSP |
| WSP |
| Wsp |
| WSP |
| WSP |
| WSP |
| WSP |
| Yorkshire Water |

Survey Questionnaire Results

Q3 Infrastructure type

Answer choices	Responses	
Transport	71.43%	40
Digital communications	3.57%	2
Energy	19.64%	11
Water and wastewater	14.29%	8
Flood management	12.50%	7
Solid waste	0.00%	0
Total respondents		**56**

Survey Questionnaire Results

Q4 UK Region(s) where you have infrastructure projects
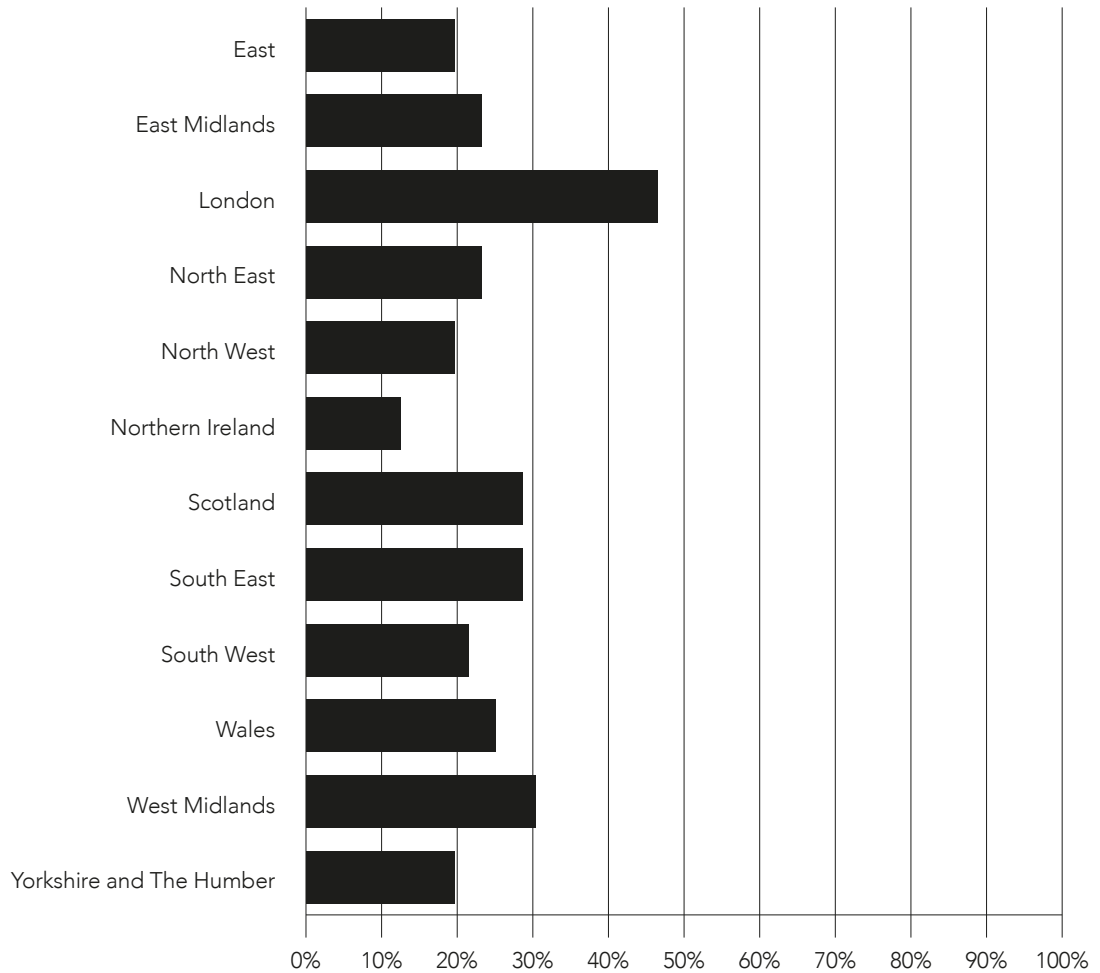
Answer choices	Responses	
East	19.64%	11
East Midlands	23.21%	13
London	46.43%	26
North East	23.21%	13
North West	19.64%	11
Northern Ireland	12.50%	7
Scotland	28.57%	16
South East	28.57%	16
South West	21.43%	12
Wales	25.00%	14
West Midlands	30.36%	17
Yorkshire and The Humber	19.64%	11
Total respondents		**56**

Survey Questionnaire Results

Q5 How would you define the role of design in infrastructure?

Answer choices	Responses	
Thinking creatively about the processes involved in providing infrastructure	14.29%	8
Problem-solving from the outset of a project	37.50%	21
Making infrastructure human-scale and user friendly	8.93%	5
Improving the aesthetics of a project	0.00%	0
Enhancing the environment	3.57%	2
Improving the quality of life for local people and nearby communities	28.57%	16
None of the above	7.14%	4
Total respondents		**56**

Survey Questionnaire Results

Q6 Do you think design can improve the processes involved in infrastructure planning?
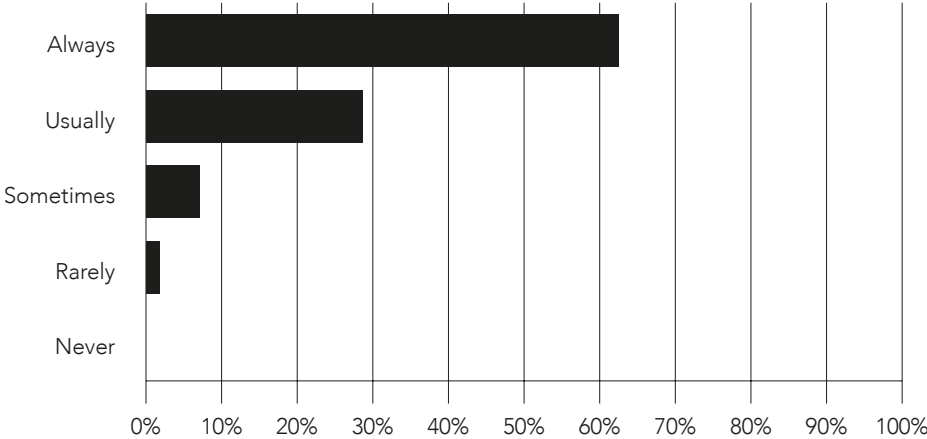
Answer choices	Responses	
Always	62.50%	35
Usually	28.57%	16
Sometimes	7.14%	4
Rarely	1.79%	1
Never	0.00%	0
Total respondents		**56**

Survey Questionnaire Results

Q7 Do you think design can be used to solve problems within infrastructure planning?
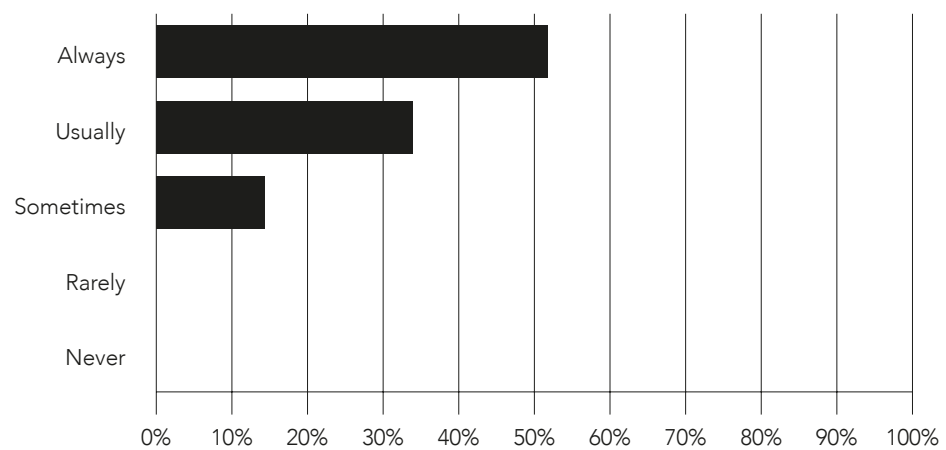
Answer choices	Responses	
Always	51.79%	29
Usually	33.93%	19
Sometimes	14.29%	8
Rarely	0.00%	0
Never	0.00%	0
Total respondents		**56**

Survey Questionnaire Results

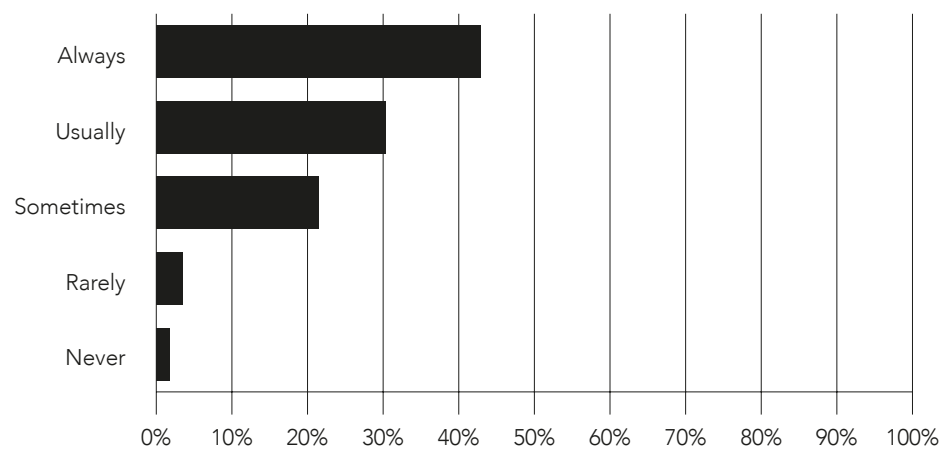## Q8 How often is design a consideration within the infrastructure projects that you work on?
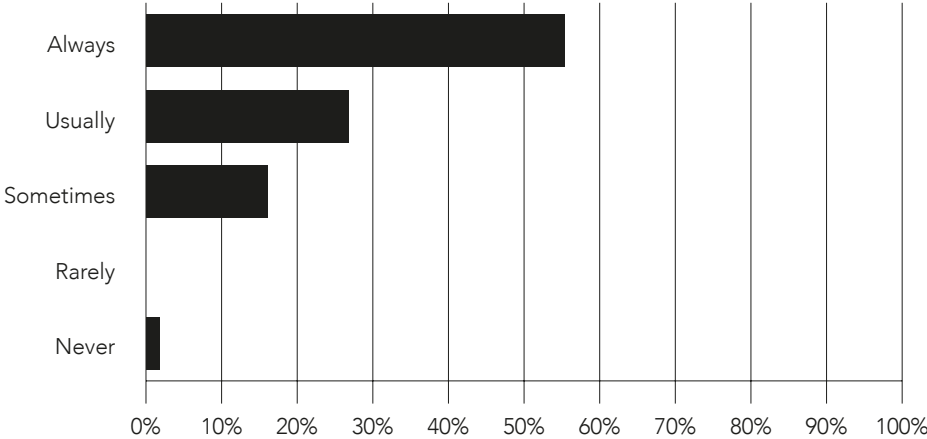
Answer choices	Responses	
Always	55.36%	31
Usually	26.79%	15
Sometimes	16.07%	9
Rarely	0.00%	0
Never	1.79%	1
Total respondents		**56**

Survey Questionnaire Results

Q9 Do you work directly with design experts as part of your projects?

Answer choices	Responses	
Always	42.86%	24
Usually	30.36%	17
Sometimes	21.43%	12
Rarely	3.57%	2
Never	1.79%	1
Total respondents		**56**

Survey Questionnaire Results

Q10 Do you commission design work as part of your projects?
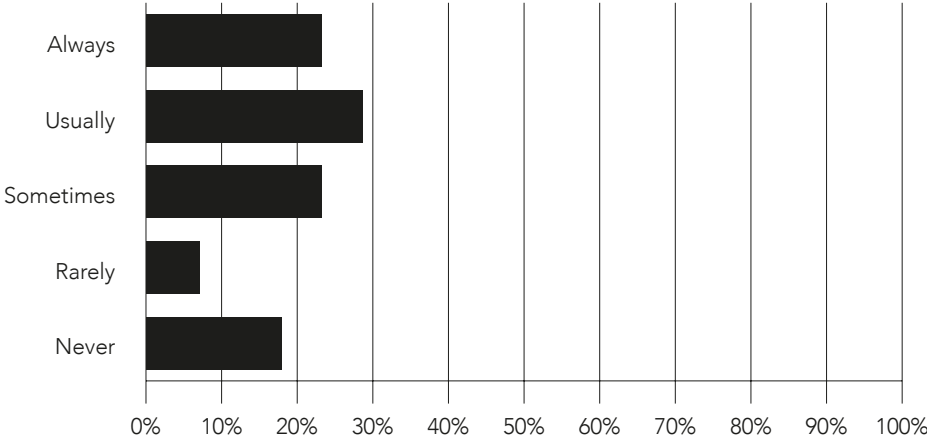
Answer choices	Responses	
Always	23.21%	13
Usually	28.57%	16
Sometimes	23.21%	13
Rarely	7.14%	4
Never	17.86%	10
Total respondents		**56**

Survey Questionnaire Results

Q11 What are the biggest risks involved with incorporating design into infrastructure projects?
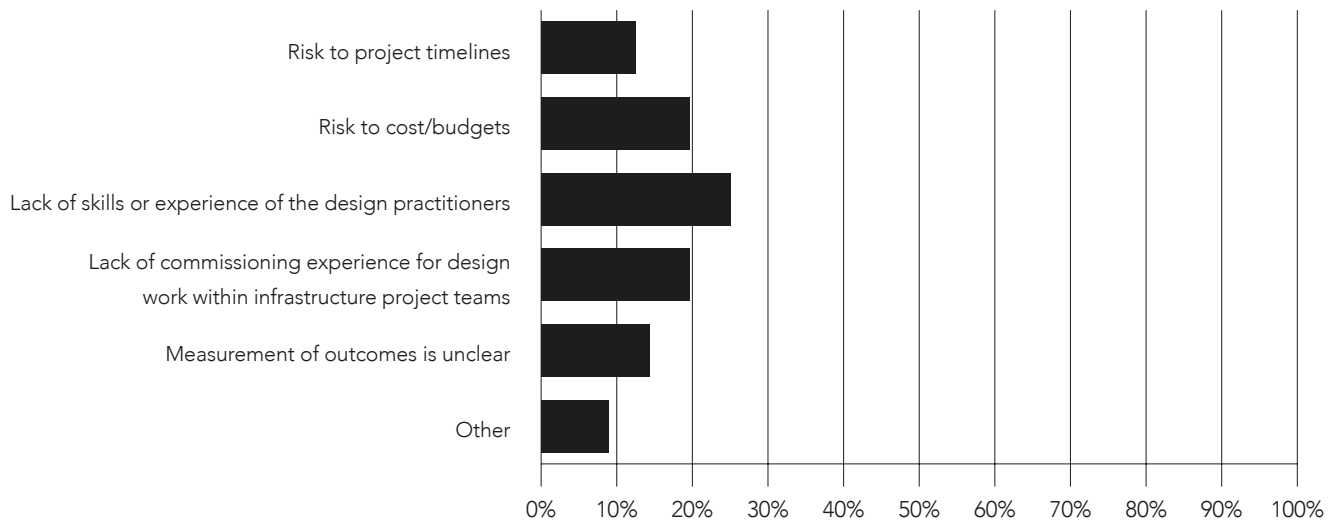
Answer choices	Responses	
Risk to project timelines	12.50%	7
Risk to cost/budgets	19.64%	11
Lack of skills or experience of the design practitioners	25.00%	14
Lack of commissioning experience for design work within infrastructure project teams	19.64%	11
Measurement of outcomes is unclear	14.29%	8
Other	8.93%	5
Total respondents		**56**

Survey Questionnaire Results

Q12 Infrastructure planning would benefit from more design expertise
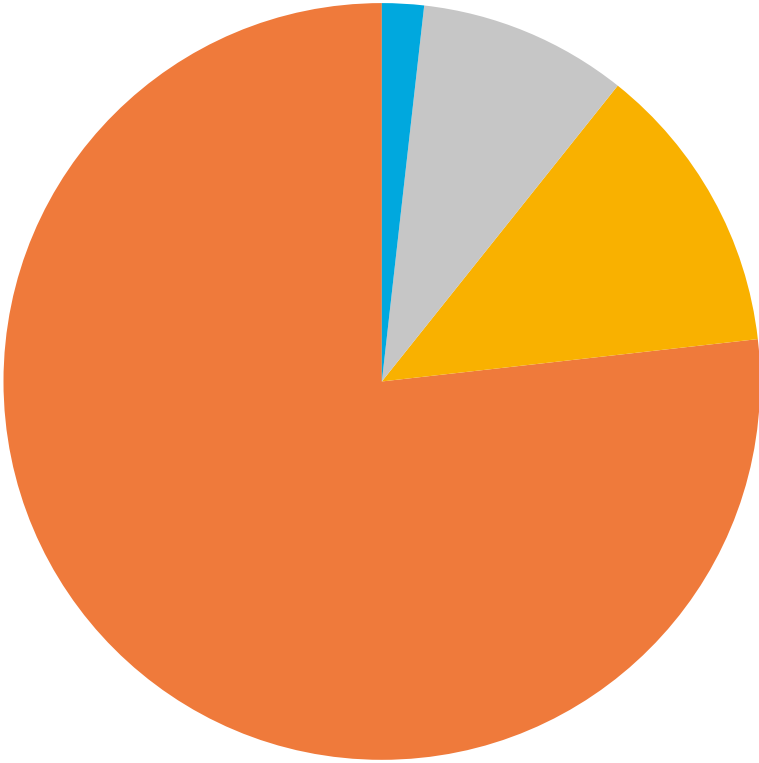
- ■ Strongly Agree 77%
- ■ Agree 12%
- ■ Neutral 9%
- ■ Disagree 2%
- ■ Strongly Disagree 0%

Answer choices	Responses	
Strongly Agree	76.78%	43
Agree	12.50%	7
Neutral	8.92%	5
Disagree	1.78%	1
Strongly Disagree	0.00%	0
Total respondents		**56**

Survey Questionnaire Results

Q13 Each infrastructure project needs a design champion at a senior level
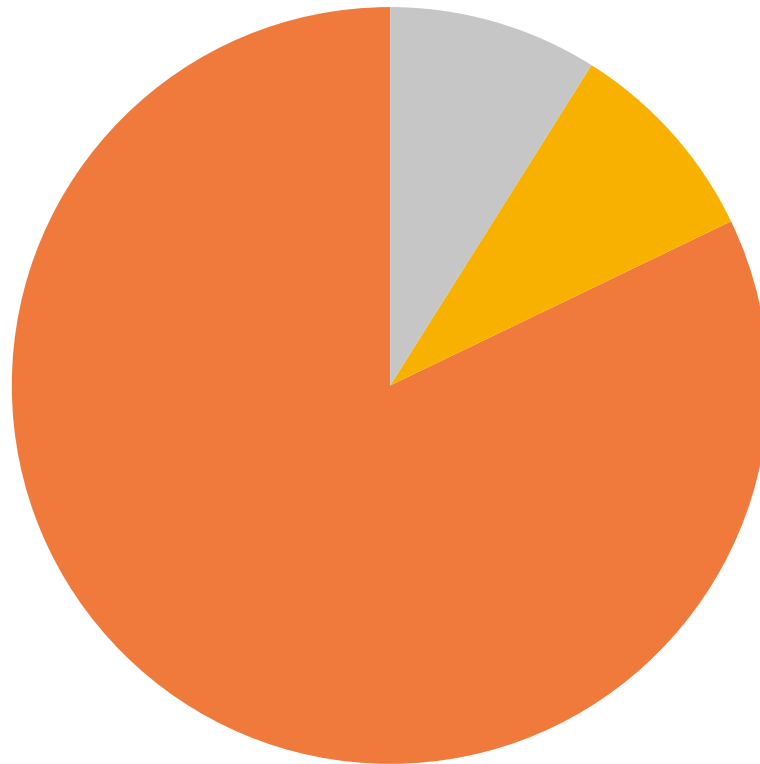
- Strongly Agree 82%
- Agree 9%
- Neutral 9%
- Disagree 0%
- Strongly Disagree 0%

Answer choices	Responses	
Strongly Agree	82.14%	46
Agree	8.92%	5
Neutral	8.92%	5
Disagree	0.00%	0
Strongly Disagree	0.00%	0
Total respondents		**56**

Survey Questionnaire Results

Q14 What are the barriers to improvements in infrastructure design?

'Design' defined as an afterthought of 'making things pretty'. Poor leadership in decision-making. Really poor procurement - go in cheap and then pick up the pieces.
A full understanding of the risks and their effects arising from changes to the accepted design norms, leads to safety-first thinking - stick to the standard, do it the way granddad did.
Adopting Authrorites
Communication
Cost
Cost and programme deadlines
Cost and timescale concerns - do the cheapest and easiest job
Cost implications, traditional accepted practices
Designers producing impractical and overly expensive designs
Early design involvement, early contractor involvement, design champions, early funding, incentives
Hostility to innovation especially Low commitment to digitisation of brief/requirements and Low commitment to digitisation of proposals.
Initial cost v whole life costing
Interfacing wiyth old infrastructure that does not meet current standards
Keeping team and individuals focused
Lack of cascade of lessons learnt from previous similar projects by project designers & delivery teams
Lack of experience in whole-project design
Lack of finance - striving for minimum cost solutions from Day 1.
Lack of systematic, cross-sector planning
Lack of understanding of design's value by those commissioning or project managing - seen as a 'pretty add on' rather than essential and integral. Engineers tend to be seen as essential, designers are not always. Those with no design training often overestimate their skills. Equally, designers can be seen as frustrating. Design can be seen as too complicated or a 'spanner in the works'. Infrastructure seen as 'hard', design seen as 'soft' - not seen as compatible. Public procurement can be a barrier to using design expertise in large-scale projects. Infrastructure led by local authorities can be led by teams with no design expertise, or with a lack of cross-disciplinary working.
Lack of vision
Management
Many client organisations - including local authorities, and rail / roads bodies - lack the commissioning expertise. Exceptions include e.g. Transport for London or City of London that can assemble multi-disciplinary teams to manage different design processes.
Not using the most up to date technology
Open-Ended Response
Over emphasis on process controls and reduced emphasis on direct execution of outline and detailed design. Project Managers' lack of direct engagement with design challenges leading to their lack of understanding (and interest) of strategic issues. The Project 13 initiative has identified a staggering 51% of project cost in preconstruction activities and this seems likely to have arisen from this over-emphasis on process controls and procedures leading to inefficient design management.

Survey Questionnaire Results

Perceived cost.
PI Insurance - Who covers?
Planning policy and political expediency
Poor specification from clients, poor contracting methods to consultancies which do not penalise poor work, consultants not considering constructability in the design, leading to late rework
Procurement, sensible time to get the right solution in detail. only very high level proposals with out the detail is where many designs fall down or require more work to solve
Procurement route - ensuring that the 'improved' design is built
Programme and cost
Programmes that are politically driven. There is never time to get it right first time but there is always time to redesign to accommodate political influences
Project managers who do not want to listen
Return on investment
Shortage of quality designers.
Slavish obedience to codes - think Grenfell
Strategic long-term planning and consistent policy from government to ensure stakeholder confidence
The asset owner/ promoter must employ the Designer and manage the project. The contractor's design must be limited to temporary works.
The false belief that good design adds cost to projects when the reverse should be true
The time scales and restrictions set by clients
Time and cost
Timescales and budget
Too short a lead-in, short sighted planning. Good teams cannot be created on a whim. They must build around the challenge and stay with it.
Uncertainty over need
Unsustainable architecture
Unwillingness to incorporate new ideas and new ways of thinking into designs
Unwillingness to spend time in design phase - get to site quickly
Value management only looking at first costs and ignoring whole life costing, gross over design e.g. Of railway signal and overhead line structures when compared with the standard designs used by BR.
What are the barriers to improvements in infrastructure design?
Willingness to pay from regulators, customers or capital investors for design in what is often deemed a commodity/ expectation/essential service. Potentially resulting in stifling innovation, design, and environmental improvement opportunities.

Survey Questionnaire Results

Q15 In your opinion, what is the best designed infrastructure project and why?

Aqueduct!
Bridleway network
Brunel railways
Can't say
Cheonggyecheon River Restoration
Crossrail
Crossrail - return of new infrastructure to economy. Highway transportation - relieving congestion
Crossrail (although I've not had direct involvement, it appears to have had a clear vision and used effective tools to aid collaboration)
Crossrail hopefully
Crossrail springs to mind
Crossrail. It is the first new rail line to be constructed across London for some considerable time and it will integrated with London existing rail and tube lines. It will improve passenger capacity by 10% within London.
CTRL (HS1)
Culture
European High Speed Rail Network - including HS1 - excluding HS2
Examples of public transport interchanges that work well at a human scale - Nantes, centre of Biel/Bienne, Some Swiss railway stations e.g. Bern station
Gateshead millennium bridge - form and function are one and the same. Completely integrated design
Hong Kong Mass Transit
Hong Kong MTR
HS1
HS1 CTRL on time, budget and programme using a diverse team.
HS1 notably St Pancras International & Kings Cross lands
Integrated design I think the best design needs to be "buildable" and design that gives certainty. I think from a construction perspective no design is full prove. Self praise, I feel London Bridge Station Redevelopment is well designed infrastructure project with many many stakeholders to manage. Thus design costs are expensive
Jubilee line extension & Hungerford bridge
Kings Cross station upgrade works
Liege Railway Station, Belgium.
London 2012 Olympic structures
London Bridge Station - the works recently completed at London Bridge are both architecturally striking and also create a really effective use of space and place for people to come to and pass through. The also enhance the local built environment and will act as a regeneration catalyst in the area.
London Bridge Station Redevelopment
Millau Viaduct - impressive engineering problem that also considered the view of those on the bridge as well as the view of the infrastructure itself from elsewhere

Survey Questionnaire Results

N
N/A
Norwegian hydro power project - 2016 - entirely paperless.   Oslo terminal 2 - 2017 - entirely model (not document/ drawing) based
Not able to answer
Not sure
Rotterdam Central Station upgrade is fantastic.
The 'super' sewer
The Dryline, New York City. City flood protection infrastructure.
The London sewage and drainage system delivered by Joseph Bazalgette
The restored 3 London stations:- St Pancras, Kings Cross and now London Bridge.
This is an almost impossible question to answer directly because all engineers will have project favourites and for a wide variety of different reasons. Of the many Cass Hayward notable projects perhaps the Paddington Bridge Project stands out best and received many accolades including the 2006 BCIA top award. This was because it integrated design ingenuity with an adventurous approach to construction that significantly reduced the disruption to the travelling public. It was made possible only by the whole project team "buying-in" to the concept from inception to completion and all parties participating in a well planned and managed process.
WTC transportation hub
York Station track remodelling

Survey Questionnaire Results

Q16 Any other comments?

As well, why not ask us what is the worst-designed infrastructure project?

Better definition of what design means in the built environment would help

Design is a complex topic and good design must start with the Client's objectives. Clients often constrain designers within unnecessary limits with their brief and the designer has to think creatively about the processes, starting with "do we need more infrastructure?". Designers should be involved at project definition stage to ensure that the Brief is fit for purpose. The current norm where price drives everything encourages designers to do what the Client says, which may not be what he needs and definitely does not encourage innovation and good design. But commercially, it is often easier for the designer not to create waves.   By involving the designer at the Brief stage, this is less of an issue. Perhaps its time to split design into "Design" and "Design production" where design production will in future be undertaken automatically. The capability exists already to, for example, automatically fully detail a concrete slab from basic input parameters. As long as the design is robust, the design production can be undertaken by data entry clerks with no design knowledge. PS Q5 asks for up to 2 but only let me mark one response.

Early effective communication & collaboration between designers and project delivery teams is a fundamental for successful outcomes

I work a lot on public transport schemes to unlock housing areas. The integration of infrastructure design and the design of the development beyond the red line boundary can be challenging - lost of questions of delivery process, timing and sometimes funding.

It is good design and construction. All infrastructure projects are very complex. A good detailed design can help set the construction in the right direction. Stick to the build plan and design it for the end user

Need to adopt information 'pull' up through design/engineering chain and up through construction chain towards asset owner/operator

Needed a definition of design for the early questions in this questionnaire.

Set fee targets for Designers to save on Construction costs

The one Question offering 2 selections didn't

The response to question 14 represents a serious personal concern after over 40 years' experience in the industry. Whilst design products may have good appearance due to modern digital processing this can hide the true quality of the design. Modern codes and procedures do not seem to encourage innovation and advancement in design techniques leading to more efficient construction seems to have stalled. This apparent renewed emphasis on design is most welcome!

There is never enough time in project timescales to refine design, has to be right first submission. Allow more time and "build" contractor input.

To your question 11 - we don't see 'design' as something that is either incorporated or not incorporated into a scheme. Every scheme is designed, some are designed well, some poorly. The key is to establish a team of experts who constantly work to improve the design.

We are designers and want to design but can all too often lose that opportunity by the client organisations shortfall and there lack of planning and coordination becoming our programme problem. Client has 5 years to make a decision then wants it delivered to a vague brief in 6 months. Early designer involvement could improve this.

What did you mean by design? We're you thinking of aesthetics? Everything is designed to some extent and needs to be designed well.

Associations and Businesses

Association for Project Management

Arup (Infrastructure)

Chartered Institution of Highways and Transportation

Cleveland Institution of Engineers

Energy Institute

Institute of Highway Engineers

Institute of Road Transport Engineers

Institution of Civil Engineers

International Council on Systems Engineering

Thames Tideway Tunnel

Queen Elizabeth Prize for Engineering

Women's Engineering Society

Interviewee List

Andrew Wolstenholme, former Chief Executive of Crossrail, civil engineer at BAE Systems

Angus Walker, Partner at Bircham Dyson Bell

Ann Bentley, Chairman, Rider Levett Bucknall

Cavendish Elithorn, Director, Major Rail Project Development, Department for Transport

Dr Colin Church, Chief Executive Officer, Chatered Institute of Waste Management

Emma Smailes, Operations Manager, Environment Agency

Ester Kurland, Head of Urban Design, Transport for London

Harbinder Birdi, Partner, Hawkins Brown

Harry Armstrong, Head of Technology Futures, Nesta

Joshua Dickerson, Associate at Deetu and member of NIC Young Professionals Panel

Les Sparks, architect and town planner

Mark Thurston, Chief Executive, HS2

Martin Stockley, Deputy Chair, HS2 Design Panel and member of Highways England Design Review Panel

Matthew Ball, Manager, Ofgem

Sheena Bell, Senior Associate and Landscape Architect, Gillespies

Victor Frebault, Consultant, Arup and member of NIC Young Professionals Panel

Workshop Attendee List

Alison Caldwell, Principal Engineer, WSP

Annette Jezierska, Co-founder, The Future Fox

Charlotte Mitchell, Associate, Quod

Sakthy Selvakumaran, Civil Engineer, University of Cambridge

Daisy Froud, Strategist and Academic, Bartlett School of Architecture

Esther Kurland, Head of Urban Design, TfL and Director, Urban Design London