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RESEARCH ARTICLE

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Development Expectation Gap of Design-Build Contract Delivery in China's Civil Aviation Infrastructure Projects

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Abstract: Despite the reduction in cost and schedule, and the improvement of quality and safety, the design-build (DB) method in China's civil aviation infrastructure projects (CAIPs) has not been widely used and not reached the full value. To know what the development expectation gap is, it is necessary to determine the disparity in developmental prospects of the DB method in China's CAIPs. To this end, this paper first conducted a survey to know what the development expectation is through 69 subjects working in CAIPs. After that, 25 cases data were collected to get the actual development of the DB in CAIPs. The key findings from the comparison between the expectation and actual development show that the design institutes play a leading role in the popular form of consortium in the DB mode, and the DB method is mainly used in CAIPs with small investment. In addition, this paper also analyzes how some causes contributed to the development gap and presents three strategic actions. This study not only shows the development status of the DB method in CAIPs but also presents the reasons contributing the development expectation gap, along with the potential strategic actions, which can be as a reference for scholars and practitioners.

Keywords: design-build (DB), survey expectations, actual development, development expectation gap

1. Introduction

In the past, most of the civil aviation infrastructure projects (CAIPs) have been delivered by using the design-bid-build (DBB) method, which also refers to as the "traditional" delivery method including three key stakeholders, namely owner, designer, and builder. In the above organization, the owner monitors and controls the project performance of the designer's and builder's activities to assure adherence to contract requirements [1–3]. With the rapid development of civil aviation infrastructure in recent, aiming at lowering project costs, expediting schedules, improving quality and safety, and so on during the design and construction phases, it increasingly has been using the alternative project delivery method called design-build (DB), which includes two key stakeholders, namely owner and the general contractor. In this organization, the owner contracts with a single entity responsible for both design and build [3, 4]. Because DB is a single entity which is responsible for design and build, the adversarial relationship arose in DBB is obviated [5]. The reason lies in that the DB method can bridge the gap between the design and build, reduce cost and time, and clearly clarify the responsibilities. In addition, the contractor in DB mode usually has potent ability and professional knowledge in complex projects, such as CAIPs. Therefore, despite the scope of DB, it can also be applied in CAIPs whose owner pays more attention to reducing cost and time.

The DB method has become increasingly common in the architecture, engineering, and construction industry [6–10], and findings show the efficacy of DB in providing superior cost and schedule outcomes over the DBB method [2, 11–14]. The airport construction is no exception [15–18]. Since 2020, runways and buildings in airport have been delivered by using the DB method in China; however, the limited applications do not reach its full value, and the development of the DB method in CAIPs falls far behind other industries. Therefore, the author employed a survey and a cases analysis to know the development expectation gap and provide some strategic actions on it. The main contribution of this paper is that this study not only shows the development status of the DB method in CAIPs but also presents the reasons contributing the development expectation gap, along with the potential strategic actions, which can be as a reference for scholars and practitioners.

This paper is organized as follows. Section 2 presents the research method. Then, Sections 3 and 4 describe the survey and the cases. Section 5 analyzes the development expectation gap, and Section 6 concludes the paper with a discussion and recommendations for future work finally.

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2. Research Method

Since 2020, the DB method has been introduced in the China's civil aviation infrastructure construction industry, and also is being concerned how to develop. Around this theme, this paper adopts the research method that analyzes the development expectation gap between survey expectations in 2020 and cases practice since 2020. Figure 1 illustrates research method in this paper, the horizontal axis represents the time (month number), and the vertical axis represents the number of cases; as time goes forward, there will be 25 cases by the end of 2022 (36 months). From May to October 2020 (5–10 month), we developed a survey and established some expectations for the development of the DB method in the future in China. The actual development based on the 25 DB cases was collected at the beginning of 2023.

As mentioned above, the method comprises the questionnaire survey and cases analysis. In terms of the questionnaire survey, the steps included clarifying the objectives, designing the questionnaire, selecting the survey method, conducting the survey, and data analysis. In detail, based on a project that aims to explore the construction general contracting mode in CAIPs, we refined the core content and made the objective of this questionnaire, which is to explore the DB method used in the CAIPs. In line with this objective, we designed 14 questions in the questionnaire. After that, we selected respondents and the online method via WeChat. Finally, we got 69 valid results and adopted the statistical description to analyze the collected data (see Section 3).

With respect to cases analysis, it mainly contained data collection and analysis process. We used the keyword "general contracting" to search for empirical projects in an official website, including construction content, planned schedule, etc., of the projects, and then, we use the statistical analysis method to analyze and present these results.

3. Survey

3.1. Survey questions

In May 2020, during the construction of the first DB project in civil aviation infrastructure engineering, we developed a succinct industry-wide survey. The survey consisted of 14 questions (Table 1) that were divided into three parts and included five single choices, seven multiple choices, and two short answers. The first part was very simple, to mainly survey whether the DB method was being known, whether the method had more value compared with the DBB method, whether it was necessary to apply and promote the method in the industry, who was more suitable to lead the DB project, and do you support the promotion of the DB method in the industry? The second part was relatively complicated, to survey what causes result in the slow application and promotion of the method in the industry, what benefits, drawbacks, and concerns can it bring, what are the key capabilities of the general contractor, what are the advantages of the DB project led by design institute or construction enterprises? The third part was some supplements, to survey what problems will meet and suggestions to deal with them, and what else need to concern for the survey?

3.2. Survey results

Survey respondents represented a broad cross section of project stakeholders using DB or DBB, which includes industry management department, project owner, design institute, construction enterprises, supervision enterprises and others, a total of 69 person, and their proportions was 5.80%, 24.64%, 20.29%, 23.19%, 11.59%, and 14.49% separately.

From 9:00 on July 21 to 10:00 the next morning, a total of 69 questionnaires were sent out and all were returned via WeChat. We sorted out the survey results of single choice and multiple choice

Figure 1
Research method in this study

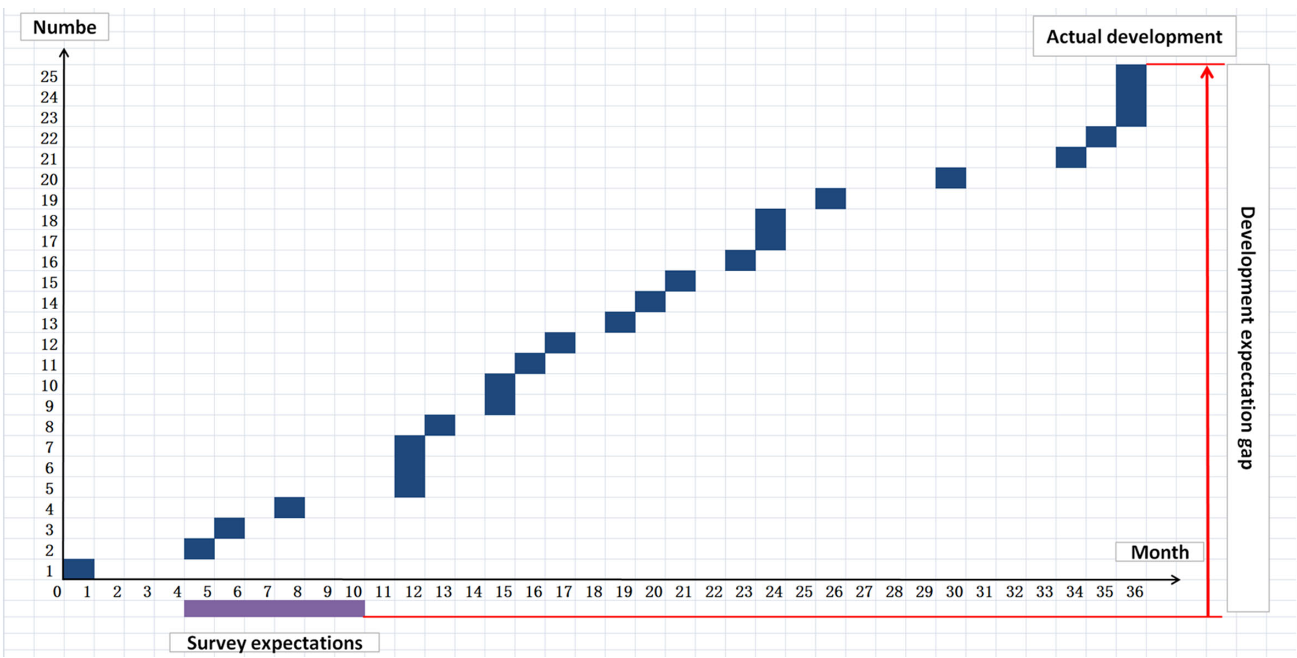
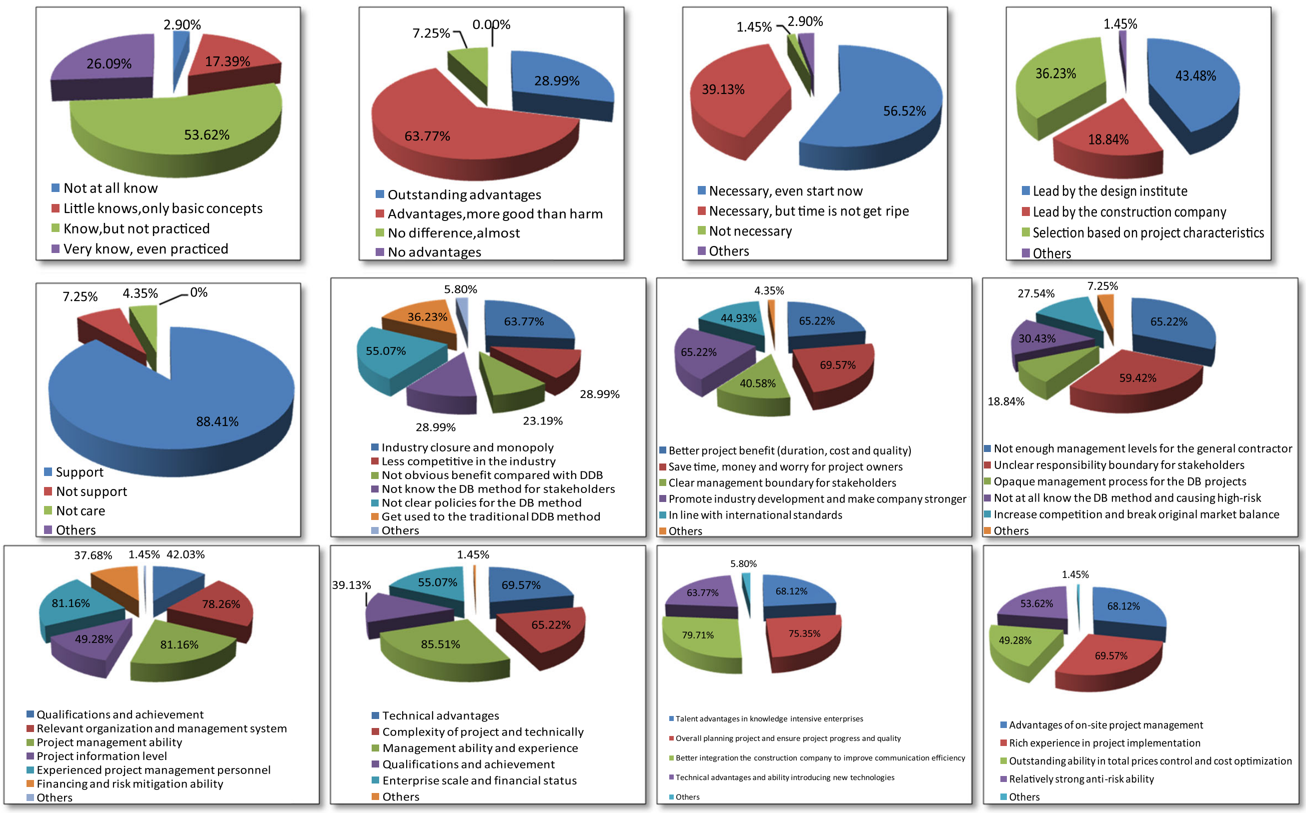


Table 1
Survey questions

Survey questions (single choice)
Q1. Do you know about the DB method?
Q2. What is the value of the DB method compared with DBB method?
Q3. Is it necessary to apply and promote the DB method in the civil aviation infrastructure industry?
Q4. Which is more appropriate to lead the DB method, design institute, or construction enterprises?
Q5. Do you support the promotion of the DB method in the civil aviation infrastructure industry?
Survey questions (multiple choice)
Q6. What causes result to slow apply and promote the DB method in the civil aviation infrastructure industry?
Q7. What benefits bring to the civil aviation infrastructure industry when applying and promoting the DB method?
Q8. What drawbacks and concerns bring to the civil aviation infrastructure industry when applying and promoting the DB method?
Q9. What are the key capabilities of the general contractor when applying and promoting the DB method?
Q10. What factors are to be considered when selecting the leading party to lead the DB method?
Q11. What are the advantages of the DB method led by design institutes?
Q12. What are the advantages of the DB method led by construction enterprises?
Survey questions (answer question)
Q13. What problems you will meet when applying and promoting the DB method? And what are your suggestions?
Q14. What else need to pay attention to or supplement for the survey?

Figure 2
Survey results showed question 1 to question 12



questions using the proportion of pie chart to reflect the views of different participant, and the results are shown in Figure 2. For two short answer questions, 36 questionnaires did not answer and 15 questionnaires answered both of them. In addition to the above two cases, 17 questionnaires only answered the first question and one questionnaire only answered the second question. For the first question, difficulties mainly focused on four aspects, including lack of policy support, interference from stakeholders, not support from the owners and local governments, and lack of general contracting capacity. And suggestions included issuing industrial policies, strengthening policy publicity and changing the concept of stakeholders, owners, and local governments, building the capacity of the general contractor, and making competent units to be general contractors. For the second question, attention or supplement mainly focused on two aspects, including risk and response, management mode exploration.

From the collected questionnaire data, 88.41% of respondents would love to promote the DB method in practice, even though it has been the initial stage in China's CAIPs. Another interesting finding is that the leader in DM mode is mostly played by the design institute whose professional knowledge is of importance in ensuing the success of the CAIPs. In addition, when considering the use of the DB method, management ability and experience are the first factors, accounting for 85.51%.

4. Cases

4.1. Data collection

The website (https://zbtb.caac.gov.cn/) is a platform for China Civil Aviation Engineering Construction Project Tendering and Bidding, where the data of the DB projects, including bidding information, bid winning information, completion information, and so on, can be found. We entered the keyword "general contracting" in the above website on January 1, 2023 and a list can be obtained. The list included the 25 DB projects whose procurements were qualifications-based for both design and build. Table 2 shows those projects by name.

According to the relevant laws and regulations in China, design units with civil aviation grade A or B or comprehensive grade A can participate in the civil aviation engineering construction project design bidding. In China, the civil aviation infrastructure construction includes airport flight area, terminal area, airport perimeter, civil aviation safety, air traffic control system, and other infrastructure construction. And the CAE construction is subdivided into 4 types, namely Airport Pavement Engineering (APE), Air Traffic Control and Weak Current Engineering (ATC), Airport Visual Aids Engineering (AVAE), and Airport Fuel Supply Engineering (AFSE). Therefore, construction enterprises with the above four A-level or B-level qualifications can participate in the construction bidding of corresponding professional CAE construction projects. Among the 25 DB projects, 24 projects won the bid in the form of consortium, and only the No. 17 project (Jiangxi Jingdezhen Airport Flight Area Support Capacity Improvement and Reconstruction Project) independently won the bid by Ycih No. 4 Construction Co., Ltd. In addition to the consortium leader, we also collected the 25 DB projects important information, including bid winning amount, bid winning date, and contract duration. Table 3 shows the main characteristics of the 25 DB projects.

4.2. Practice results

The 25 DB projects reflect civil aviation infrastructure construction across several provinces in China. Figure 3 shows geographical distribution of those projects ($N = 25$), along with the number of projects from each province. Provinces with more than three DB projects had two, which were Xinjiang and Tibet. Provinces with two DB projects had five, which were Yunnan, Guangxi, Jiangxi, Hubei, and Shanxi. Provinces with one DB project had 4, which were Zhejiang, Henan, Shanxi, and Tianjin.

Table 3 shows that 13 units shared the 25 DB projects as the consortium leader, of which six design institutes shared 18 projects, accounting for 68%, and of which seven construction enterprises shared eight projects, accounting for 32%. Figure 4 illustrates percentage of who led the 25 DB projects. Among the design institutes, Civil Aviation Airport Planning Design Research

Table 2
The 25 DB projects by name in the civil aviation infrastructure construction industry since 2020

No.1. Guangxi Beihai Airport Apron Expansion Project
No.2. Tianjin Airport Win the "Blue Sky Defense" Engineering and Equipment Procurement Project
No.3. Xinjiang Turpan Airport Reconstruction and Expansion Project (Civil Aviation Engineering)
No.4. Jiangxi Ruijin Airport New Construction Project (Civil Aviation Engineering)
No.5. Henan Xinzheng Airport Phase III Expansion Project (North Cargo Area and Airfield Supporting Works)
No.6. Xinjiang Urumqi Regional Control Center UHF Communication Blind Filling Project
No.7. Shanxi Wusu Airport Flight Area West Taxiway Reconstruction and Expansion Project
No.8. Hubei Tianhe Airport the Third Runway Supporting Apron and Facilities Project
No.9. Xinjiang Alar Airport New Construction Project (Civil Aviation Engineering)
No.10. Xinjiang Kuqa Airport Apron New Added Project
No.11. Tibet Dingri Airport New Construction Project (Civil Aviation Engineering)
No.12. Tibet Gongga Airport Test Project of Foundation Treatment and Earthwork for the New Second Runway
No.13. Xinjiang Turpan Airport Reconstruction and Expansion Project (Terminal Area Phase I Weak Current System Project)
No.14. Yunnan Changshui Airport East Airfield Underpass and Comprehensive Pipe Gallery Construction Project
No.15. Shanxi Wusu Airport Flight Area Asphalt Pavement Overlay and Reconstruction Project
No.16. Xinjiang Airport Group Regional Control Center Project (Civil Aviation Engineering)
No.17. Jiangxi Jingdezhen Airport Flight Area Support Capacity Improvement and Reconstruction Project
No.18. Xinjiang Urumqi Airport Passenger Baggage Full Process Tracking System Airport End construction project
No.19. Tibet Gongga Airport Flight Area New Construction Second Runway Project
No.20. Hubei Tianhe Airport Third Runway New Construction Project
No.21. Guangxi Wuxu Airport Airside Transfer Center and International Waiting Area Construction Project
No.22. Tibet Heping Airport Upgrading Project Lot I
No.23. Zhejiang Jiaxing Airport Reconstruction and Expansion Project (Terminal Area Phase I Weak Current System Project)
No.24. Shanxi Fugu Airport New Construction Project (Civil Aviation Engineering Lot N1)
No.25. Yunnan Xishuangbanna Airport Phase IV Reconstruction and Expansion Existing Runway Covering Project

Figure 3
Geographical distribution of those projects ($N = 25$)

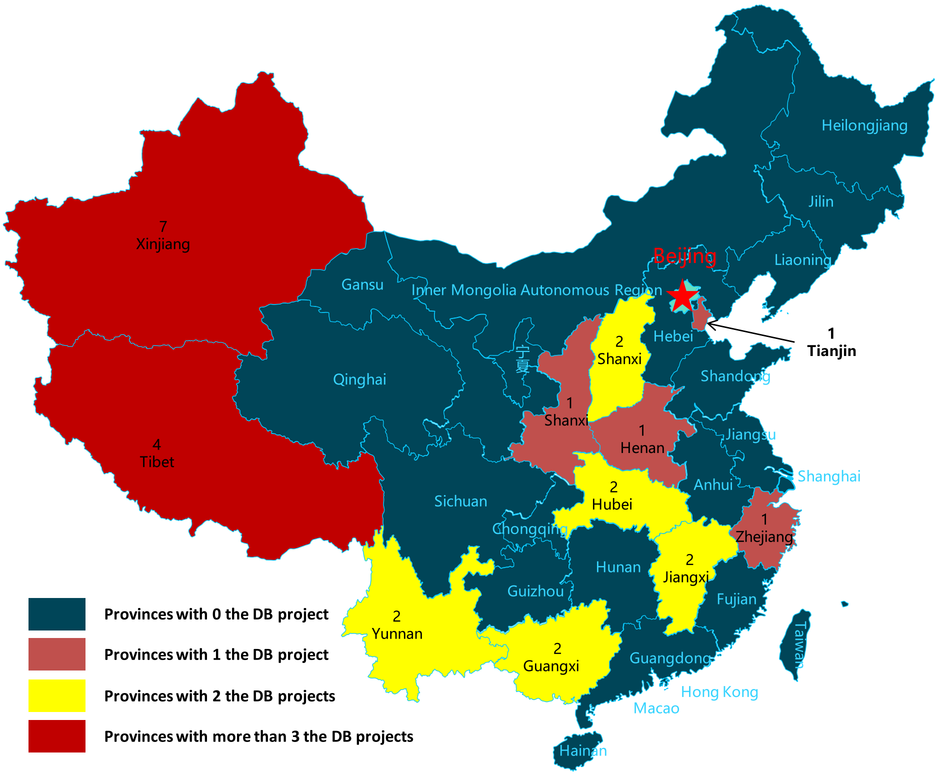
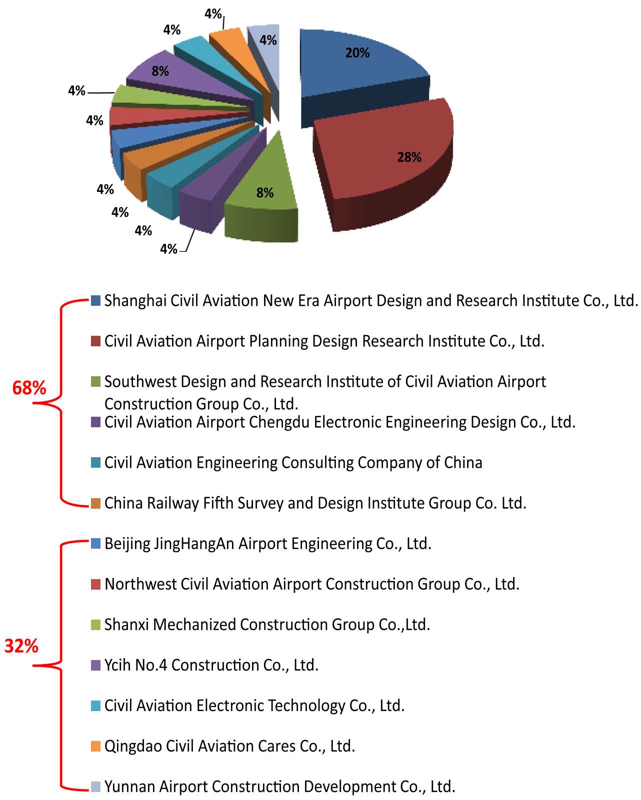


Figure 4
Percentage of who led the 25 DB projects



Institute Co., Ltd. has seven projects, including No.2, No.3, No.6, No.8, No.12, No.19, and No.20. Then Shanghai Civil Aviation New Era Airport Design and Research Institute Co., Ltd. has five projects, namely No.1, No.4, No.5, No.21, and No.23. Southwest Design and Research Institute of Civil Aviation Airport Construction Group Co., Ltd. also has two projects, including No.11 and No.22. The remaining three design institutes were respectively responsible for one project. Among the construction enterprises, Ycih No.4 Construction Co., Ltd. has two projects, namely No.14 and No.17, and the remaining six design institutes were, respectively, responsible for one project. Due to the complexity and variety of CAIPs, various professional knowledge is required in one CAIP, so that only one institute cannot fully achieve all of the tasks in CAIPs. As a result, the consortium is the main stream form to win the bid. Further, from the collected data, despite the popularity of the consortium, there are few institutes that have the ability to win bids. Meanwhile, based on the analysis above, the design institute has played a leader role in conducting the DB method in China's CAIPs, which is the same with that in the collected questionnaire data.

Nine projects have cost less than ￥100M, which are No.13, No.6, No.18, No.15, No.10, No.22, No.17, No.7, and No.25, accounting for 36% in number and 4% in amount. Seven projects have cost with ￥100M–500M, which are No.21, No.16, No.12, No.2, No.1, No.3, and No.14, accounting for 28% in number and 10% in amount. Five projects have cost with ￥500M–1000M, which are No.9, No.4, No.23, No.8, and No.24, accounting for 20% in number and 27% in amount. The remaining projects including No.20, No.11, No.19, and No.5 cost more than ￥1000M, accounting for 16% in number and 59% in amount.

Table 3
The 25 DB projects main characteristics

Project No	Consortium leader	Bid winning amount (RMB Millions)	Winning Bid date	duration (days)
No.1	Shanghai Civil Aviation New Era Airport Design and Research Institute Co., Ltd.	162.99	2020/1/19	300
No.2	Civil Aviation Airport Planning Design Research Institute Co., Ltd.	158.28	2020/5/19	98
No.3	Civil Aviation Airport Planning Design Research Institute Co., Ltd.	182.14	2020/6/9	194
No.4	Shanghai Civil Aviation New Era Airport Design and Research Institute Co., Ltd.	653.61	2020/8/26	720
No.5	Shanghai Civil Aviation New Era Airport Design and Research Institute Co., Ltd.	2,720.55	2020/12/17	386
No.6	Civil Aviation Airport Planning Design Research Institute Co., Ltd.	16.99	2020/12/21	400
No.7	Shanxi Mechanized Construction Group Co., Ltd.	95.13	2020/12/22	730
No.8	Civil Aviation Airport Planning Design Research Institute Co., Ltd.	736.97	2021/1/7	540
No.9	China Railway Fifth Survey and Design Institute Group Co. Ltd.	520.74	2021/3/17	265
No.10	Civil Aviation Engineering Consulting Company of China	64.99	2021/3/22	200
No.11	Southwest Design and Research Institute of Civil Aviation Airport Construction Group Co., Ltd.	1,457.97	2021/4/28	762
No.12	Civil Aviation Airport Planning Design Research Institute Co., Ltd.	145.78	2021/5/24	140
No.13	Civil Aviation Airport Chengdu Electronic Engineering Design Co., Ltd.	12.89	2021/7/6	183
No.14	Ycih No.4 Construction Co., Ltd.	434.65	2021/8/10	800
No.15	Northwest Civil Aviation Airport Construction Group Co., Ltd.	22.54	2021/9/19	90
No.16	Civil Aviation Electronic Technology Co., Ltd.	125.60	2021/11/1	212
No.17	Ycih No.4 Construction Co., Ltd.	87.92	2021/12/17	150
No.18	Qingdao Civil Aviation Cares Co., Ltd.	20.46	2021/12/24	193
No.19	Civil Aviation Airport Planning Design Research Institute Co., Ltd.	2,054.60	2022/2/21	580
No.20	Civil Aviation Airport Planning Design Research Institute Co., Ltd.	1,260.52	2022/6/21	730
No.21	Shanghai Civil Aviation New Era Airport Design and Research Institute Co., Ltd.	121.62	2022/10/10	426
No.22	Southwest Design and Research Institute of Civil Aviation Airport Construction Group Co., Ltd.	74.17	2022/11/28	472
No.23	Shanghai Civil Aviation New Era Airport Design and Research Institute Co., Ltd.	696.17	2022/12/6	760
No.24	Beijing JingHangAn Airport Engineering Co., Ltd.	752.04	2022/12/6	1096
No.25	Yunnan Airport Construction Development Co., Ltd.	98.41	2022/12/28	210

Figure 5 illustrates the proportion of the number and amount. One interesting finding is that currently the DB method mainly is used in the CAIPs whose cost is less than ￥100M, meaning it has not been widely accepted by China's civil aviation construction industry, especially in some large volume projects.

Figure 5
Proportion of number and amount for project cost sizes

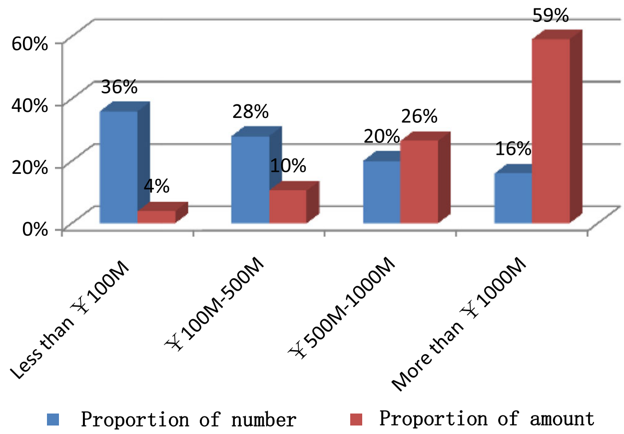


Table 4
The 12 completed DB projects actual duration

Project no	Contract duration (days)	Commencement date	Completion date	Actual duration (days)
No.1	300	2020/2/25	2020/8/26	183
No.2	98	2020/7/1	2020/9/10	71
No.3	194	2020/6/10	2020/11/6	149
No.5	386	2020/12/23	2022/5/19	512
No.8	540	2021/4/1	2022/1/19	293
No.9	265	2021/3/24	2022/1/20	302
No.10	200	2021/4/20	2021/12/22	246
No.12	140	2021/8/17	2022/5/5	261
No.13	183	2022/3/1	2022/8/3	155
No.15	90	2022/5/17	2022/8/8	83
No.17	150	2022/3/3	2022/7/31	150
No.18	193	2022/1/11	2022/4/28	107

By the end of 2022, a total of 12 projects have been completed, which were No.1, No.2, No.3, No.5, No.8, No.9, No.10, No.12, No.13, No.15, No.17 and No.18, of which 11 projects finished relatively quickly, less than 1 year to build, only the No.5 project has been actually completed for more than 1 year, reaching 512 days, exceeding the contract duration which was 386 days. Table 4 shows the 12 completed DB projects actual duration.

5. Development Expectation Gap

5.1. Development in industry

The finding in the website of China Civil Aviation Engineering Construction Project Tendering and Bidding is that the project delivery of construction projects in the past 3 years only has two methods, including DB and DBB. In the DBB method, the projects were tendering and bidding according to engineering types including APE, ATC, AVAE, and AFSE. In 2020–2022, it has respectively tendering and bidding projects including the DB and DBB methods for 398, 349, and 249, with the corresponding amounts of ￥44.57B, ￥38.93B, and ￥39.10B. Table 5 and Figure 6 show the number and amount between DBB and DB projects in 2020–2022. In terms of the number of proportion of the DB projects, from 1.76% in 2020 to 3.15% in 2021 and 2.81% in 2022, the overall proportion is not high, not reaching 5% of the total. In terms of the proportion of the DB projects amount, from 8.95% in 2020, to 9.33% in 2021, and then to 12.94% in 2022, it has become a trend of increasing year after year, but not reaching 15% of the total. Figure 7 illustrates the proportion of the DB projects in number and amount.

Table 5
Number and amount of between DBB and DB projects in 2020–2022

Year	Method	Number	Amount (RMB Billions)	Total amount (RMB Billions)
2022	DB	7	5.06	39.10
	APE	78	20.19	
	ATC	34	3.52	
	AVAE	100	9.07	
	AFSE	30	1.26	
2021	DB	11	3.63	38.93
	APE	128	25.16	
	ATC	40	3.83	
	AVAE	143	5.49	
	AFSE	27	0.82	
2020	DB	7	3.99	44.57
	APE	169	28.24	
	ATC	56	4.12	
	AVAE	144	7.72	
	AFSE	22	0.5	

Figure 6
Number and amount of between DBB and DB projects

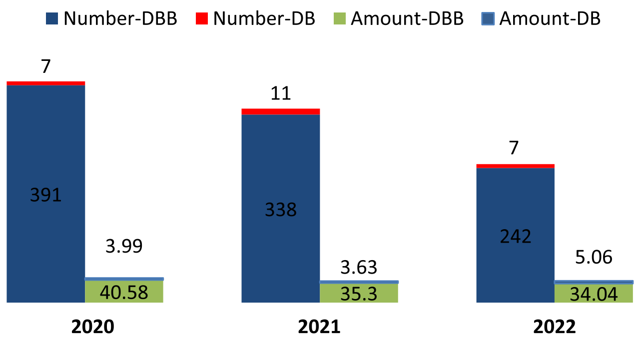
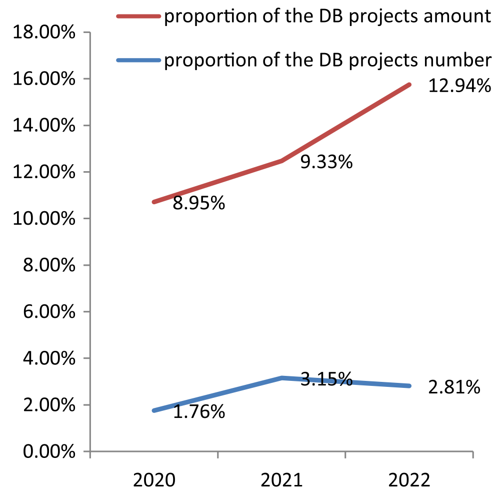


Figure 7
Proportion of the DB projects in number and amount



In the survey, Q3 and Q5 were related to developing the DB method, 56.52% of survey respondents thought it was necessary to apply and promote the DB method in the civil aviation infrastructure industry, even starting immediately. And 88.41% of survey respondents supported the promotion of the DB method in the civil aviation infrastructure industry. But, the proportion of the DB projects in number and amount in reality showed that number was not reaching 5% of the total and amount was not reaching 15% of the total. Thus, the gap between actual development and survey expectation is existing in terms of number and amount and has a certain distance, compared with the data of more than 50% using the DB method in the United States construction industry. In this point, the development adopting the DB method in the China's civil aviation infrastructure construction industry has great potential.

5.2. Performance in project

Measuring the performance of the DB projects has been the subject of many research studies. The DB method has been proved the good performance in lowering project costs, expediting schedules and improving quality and safety. Cost change is defined El Asmar et al. [19] as the percentage change from the contract award value (CAV) to the final contract value (FCV) at project completion. Equation (1) illustrates how cost change was calculated for the 12 completed DB projects. Schedule change is defined El Asmar et al. [19] as the percentage change from awarded contract duration (ACD) to final contract duration (FCD) of a project. Equation (2) illustrates how schedule change was calculated for the 12 completed DB projects. In this paper, bid winning amount in Table 3 is CAV and also FCV because the lump sum contract is adopted. Contract duration in Table 4 is ACD and actual duration is FCD. Quality is judged by quality up-to-standard ration. Safety is judged by whether accidents happened. When signing the contract, the 12 completed DB projects are all required to sign safety management goal of zero accident. Table 6 shows the result from performance analysis of the 12 completed DB projects.

Table 6
Result from performance analysis of the 12 completed DB projects

Project no	Schedule Chang (100%)	Cost Chang (100%)	Quality up-to-standard ration	Accident
No.1	−39%	0%	100%	0
No.2	−28%	0%	100%	0
No.3	−23%	0%	100%	0
No.5	33%	0%	100%	0
No.8	−46%	0%	100%	0
No.9	14%	0%	100%	0
No.10	23%	0%	100%	0
No.12	86%	0%	100%	0
No.13	−15%	0%	100%	0
No.15	−8%	0%	100%	0
No.17	0%	0%	100%	0
No.18	−45%	0%	100%	0

$$\text{Cost Chang}(\%) = \frac{(FCV - CAV)}{CAV} * 100\% \quad (1)$$

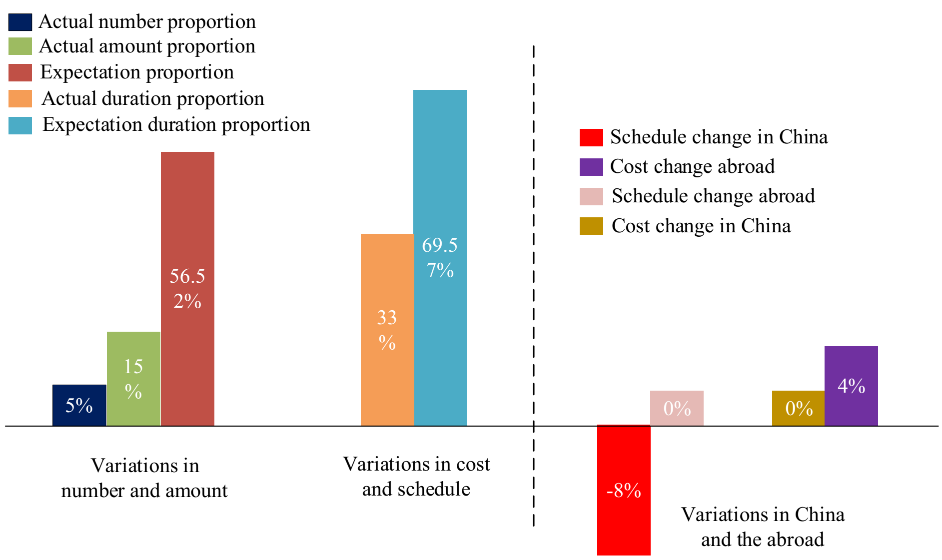
$$\text{Schedule Chang}(\%) = \frac{(FCD - ACD)}{ACD} * 100\% \quad (2)$$

In Table 6, it has seven projects that the value of Schedule Chang is negative, meaning that the construction period is shortened. The No.8 project has done the best in shortening the construction duration, reaching −46%, shortening 247 days. And there are four projects that the value of Schedule Chang is positive meaning that the construction period is extended. The No.12 project has done the worst in shortening the construction duration, reaching 86%, exceeding 121 days. Combined with the data of Tables 4 and 6, the 12 completed DB projects have a median ACD of 228.25 days and a median FCD of 209.33 days with a median schedule change of −8%. Due to the use of the lump sum contract, Cost Chang is 0% in the 12 completed DB projects. In addition, the 12 completed DB projects have a quality up-to-standard of 100% and have no accidents.

In the survey, Q2 and Q7 related to the DB method performance in a project, 92.75% of survey respondents thought it has advantages over the DBB method. 65.22% thought it has better project benefits in duration, cost, and quality when applying and promoting the DB method. And 69.57% thought it could save time, money, and worry for project owners. However, 33% of the projects have exceeded the contract duration in the 12 completed DB projects, which is unexpected for the survey respondents. Although a median schedule change of −8% in the 12 completed projects is better than 0% in the 47 collected DB transportation projects reported by El Asmar et al. [19], for the survey respondents, the expectation is higher, which is expected to further reduce the duration. In the 12 completed DB projects, Cost Chang is 0% and a median schedule change is also 0%, which is better than 4% in the 47 collected DB transportation projects that is reported in El Asmar et al. [19]. This is because the lump sum contract is an important guarantee of this value, which is also expected by the survey respondents. Figure 8 illustrates the trend variation in the expectations and actual developments, as well as in China and the abroad. From the left part of this figure, the gap between the expectations and the actual development can be witnessed obviously. While in the right part, it can be seen that the performance of the DB method in China is better than that abroad.

Therefore, the key findings from the collected cases data can be concluded from the following aspects. (1) A reduction in schedule can be witnessed obviously. Despite three projects with positive schedule changes, the median change of the 12 CAIPs is negative, reaching −8%, which is better than that abroad. (2) Due to the lump sum contract, the FCV does not exceed the ACV, which is conducive for owners to control the whole cost.

Figure 8
Trend variations



6. Conclusion and Future Works

This paper seeks to analyze the development expectation gap between survey expectations in 2020 and cases practice in the past 3 years. To this end, an in-depth survey was first conducted to obtain the expectations of the DB method in China's CAIPs. Afterwards, 25 empirical cases employing the DB method were collected to analyze the actual development of the DB in CAIPs. From the data analysis, this paper has made the following findings related to the development expectation gap:

1) The form of consortium is the main stream in China's CAIPs due to the complexity and integration of various profession backgrounds.
2) Design institutes currently have played the leading role in the consortium form in CAIPs, although there are very few institutes capable of winning bids.
3) The DB method is mainly used in CAIPs whose cost is less than ￥100M; wide application of the DB method in China's CAIPs thus should be paid more attention.
4) A reduction in schedule can be witnessed in CAIPs that have employed the DB method. Meanwhile, due to the lump sum contract, the FCV does not exceed the ACV.

Notwithstanding these, the development gap still reflects the stagnant application and promotion of DB in CAIPs. Reasons obtained from the survey (i.e., Q6) include industry closure and monopoly, less competitive in the industry, and so on (more information in Figure 2), all of which can be categorized into three classes, including the regulator system, fragmented industry, and profession talents. The detailed analysis is as follows:

1) As mentioned above, CAIPs can be divided into CAE and non-CAE. In China, the central governmental administration is in charge of the biding of the CAE, but the biding of non-CAE is responsible for local construction departments. Therefore, multiple regulators are involved in one CAIP, which can result in an impediment in promoting the general contracting, like the DB method.
2) One of the key findings in this paper is lack of corresponding institutes that can be capable of engaging in CAIPs. In this point, the China's civil aviation construction industry is less competitive, which leads to forming institutes that lack experience and achievements, not integrating resources in this industry. Thus, the fragmented industry cannot meet the requirements of applying the DB method.
3) Despite the popularity of the DB method in other projects, the CAIPs fall far behind in adopting it. This is partly because a lack of profession talents who have professional knowledge still exist here. From the survey, 28.99% of subjects were not knowing this method.

To solve these problems and promote the DB applied in CAIPs, this paper has made some strategies, including:

1) making a clear system that stipulates what types of CAIPs should employ the DB in terms of scale, investment, and complexity, and who is responsible for supervising it;
2) integrating design and build institutes to form ones that have competitive capability in achieving DB-based CAIPs;
3) enhancing staffs training, information transfer, and collaboration between staffs.

Despite these findings and conclusions presented in this paper, there are still limitations needed to be concerned. In this paper, 69 questionnaires were collected, which cannot fully represent the expectations. Another concern is that this paper focused on cost and schedule when analyzing the CAIPs' performance, not displaying the whole picture of project performance to some extent. Therefore, the future work can pay more attention to collecting more data, such as official documents, to reflect the expectation. On the other hand, more metrics such as contract change growth (CCG) and schedule change growth (SCG) [20] should be calculated to quantitatively describe the performance of CAIPs that have employed the DB method.

Ethical Statement

This study does not contain any studies with human or animal subjects performed by the author.

Conflicts of Interest

The author declares that he has no conflicts of interest to this work.

Data Availability Statement

Data available on request from the corresponding author upon reasonable request.

Author Contribution Statement

Chonghua Zhou: Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Resources, Data curation, Writing – original draft, Writing – review & editing, Visualization, Supervision, Project administration.

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