

«Research
to
Practice»

Montréal 2012
Management of Construction
RESEARCH to PRACTICE

«Du savoir
au
Savoir-faire»

Joint CIB International Symposium of
W055, W065, W089, W118, TG76,
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Volume 1*



**THE JOINT CIB INTERNATIONAL SYMPOSIUM
OF W055, W065, W089, W118, TG76, TG78,
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Conference Proceedings

Volume 1

Management of Construction: Research to Practice

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FOREWORD

Welcome, everyone!

On behalf of the organizing committee for the 2012 CIB International Conference, it gives me great pleasure to welcome you all to Montreal, the largest French-speaking city in the Americas and, more recently, the capital of pots-and-pans street concerts greeting our guests with a unique joyful clanging!

The theme of this conference, Research to Practice, focuses on what is needed to meet the challenges of the ever-evolving building industry.

Societies are resolutely turning to energy efficiency, sustainability and increased harmony between people and their environment. The industry must cope with rapidly changing standards and client needs while being faced with productivity and cost control. Creativity is definitely key to this puzzle, which will be solved through a closer relationship and understanding between research and industry.

The Montreal conference is taking a step in this direction by adding an Industry Day to its program. On Thursday, June 28, participants from all aspects of construction, planning, managing and so on will gather with researchers to hear a distinguished panel of academics and industry experts share and discuss their views on research and the building industry and the importance of the link between the two.

Afternoon sessions will then provide everyone a chance to determine and define the most promising ways to successfully develop and transfer essential knowledge in the building field.

The organizing committee has endeavoured to provide participants with surroundings that will enhance learning and networking activities for Working Commissions W055, W065, W089 and W118.

I wish you all an enlightening conference and a pleasant stay in Montreal.

Serge Boileau

Conference Chair, MCRP 2012

Is education in lean construction leading or lagging?

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Abstract

Lean Construction (LC) has rapidly increased its popularity among the major contractors in the Danish Building industry. Research indicates however that some contractors have more LC in their mouth than in their hands so to speak. A main reason for this is likely that knowledge and competences in terms of LC principle and tools is missing at the contractors. Several of the large Danish contractors have internal educational programmes aiming at learning employees at all levels LC. Also Leanconstruction.dk offers training in LC methods. One might ask if we have reached a local optimum with the current state of LC knowledge available through different educational programmes.

The most effective way to achieve increased knowledge in the building industry is to disseminate knowledge through traditional educations from Vocational training through Bachelor, Master and PhD programmes. This paper looks into how well LC is implemented and taught in the Danish educational programmes surrounding the building industry. Hence, the purpose of this paper is first to identify LC teaching at all educational levels throughout all relevant Danish schools, college universities and universities. This investigation will include both amount and topics. Secondly to investigate how well LC is adopted and applied in the Danish building industry. Thirdly, to discuss the findings and put forward the consequences of this (mis)match, and finally to propose directions for both educational institutions and practitioners.

The research has collected data from all relevant Danish institutions in terms of syllabus, course descriptions and clarifying interviews with lectures when needed. Data from the industry has also been collected through a questionnaire, interviews with key stakeholders and through Leanconstruction.dk

Keywords: Teaching, Lean Construction, Knowledge, Lean practice

1. Introduction

Lean Construction (LC) has rapidly increased its popularity among the major contractors in the Danish Building industry. Research indicates however that some contractors have more LC in their mouth than in their hands so to speak. A main reason for this is likely that knowledge and competences in terms of LC principle and tools is missing at the contractors. In a wider perspective the differences between intended and actual application of theory is important. The risk of insufficient or non-intended application is a general issue and should be treated with great awareness when designing or implementing theory. This research is, therefore, transferable and of great importance to general project management.

From an educational viewpoint it is relevant to know whether the competencies and knowledge taught at Universities, and University Colleges is leading or lagging. If teaching is lagging there will raise a quest for after education. Often this quest is overseen, and there will lack knowledge in the industry, which again can result in poor performance and lost development opportunities. Opposite, if education is leading, it might result in that knowledge is not applied in practice, and that this unused knowledge is substituting other areas of knowledge which might have been more useful to industry. The author's viewpoint is that there shall be some kind of equilibrium with a slight tendency for teaching to be leading.

The research question is simply: Is education in Lean Construction leading or lagging the construction industry?

1.1 The educational framework

In general the educational level is high in Denmark. EHEA, a Bologna follow-up group secretariat, is leading the continuous change toward transparency in the higher education area. They also keep track on each country's progress in the Bologna Scorecard. In the latest report from 2009 (Rauhvargers *et al.*, 2009). Denmark placed second in fulfilling the declaration, right after Scotland. Only implementation of the National Qualification Framework is not yet 100% in the Danish rating.

In this research the focus is on the comparable grade structure, known as the 3+2 system. The purpose is to grade the higher educational area in 3 year bachelor (both Bachelor of Science and Professional Bachelor), and a 2 year Master.

Figure 1 show an overview of the complete Danish educational system, and points out which parts are entailed in the research.

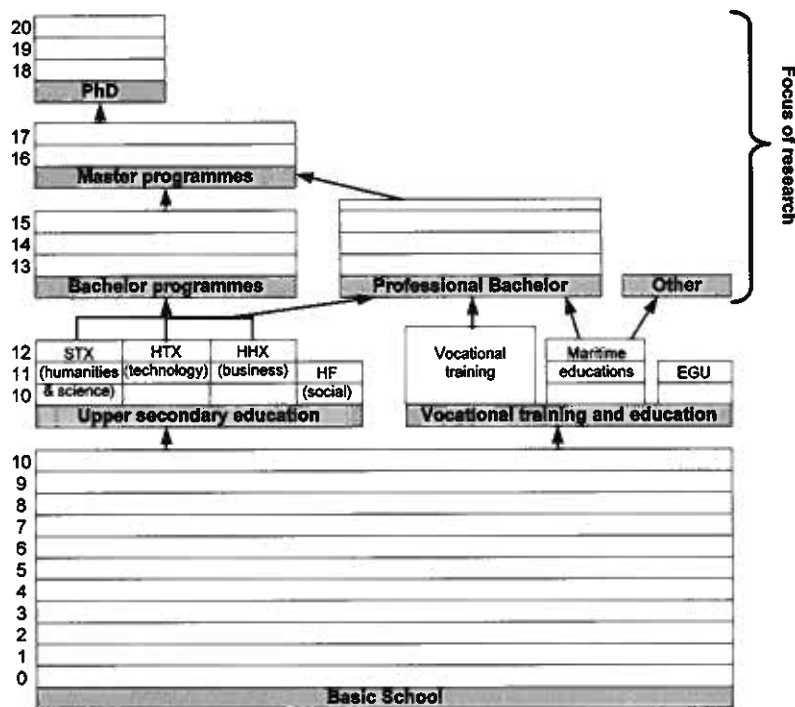


Figure 1: The educational framework in Denmark, and the focus of this research

This research narrows the focus to higher education, which includes academic and professional bachelor programmes, Master programmes and PhD. This delimitation is chosen of several reasons. Firstly, the lower part of the educational framework is general and not construction orientated. The likelihood of finding LC in curriculum is low, and does not counterbalance the effort in data collection. Secondly, this delimitation is equivalent to the undergraduate and graduates studies in e.g. the US. Thirdly, it increases the possibility of validation and international comparison

2. Methodology

This research is an explorative research aiming at identifying real life actions. The purpose was A) to identify in which extend Lean Construction is taught at Danish Universities, and B) to identify the current status of Lean Construction adaption and implementation at Danish practitioners.

The process of identifying Lean Construction in the educational systems was divided into the academic levels of Ph.D., M.Sc., and B.Sc. All Danish Universities and University Colleges were applied in the research. For all levels the data collection method was as follows:

- Search in online course catalogs (both current and past if available), and search in course description. The search looked for these keywords: Lean, Lean Construction, Planning, Scheduling, Project Management and Construction Project Management.
- If any of these keywords was identified. The findings are validated by contacting the course responsible.

To investigate the application of Lean Construction an online questionnaire survey was conducted in ultimo 2011. The questionnaire was devised with outset in designing theory presented in Forza (2002). In total 192 persons were included in the survey. It is considered acceptable that the same firm contributes to the survey with multiple questionnaires. The questionnaire was completed by 14 project managers, 17 construction managers, 16 site managers, 7 foremen, and 5 participated without stating their position. The selected participants cover the different levels of scheduling in a construction project. They represent varying opinions and contribute with different experience to scheduling. This secures an unbiased and valid survey. The questionnaire process takes its outset in the strategy presented in Akintoye and MacLeod (1997).

The survey proceeded as follows. First, an initial invitation was sent out to every participant and after two weeks a reminder was sent out to those who had not yet completed the survey. In total 59 persons completed the survey resulting in a response rate of 31%. The response rate is thus above the critical response rate of 20% (Malhotra and Grover, 1998). The questionnaire is constructed of successive questions where respondents continuous are sorted and depending on the answers can be discarded.

Therefore, the number of respondents will vary from question to question. No completed questionnaires have been rejected by the authors due to incorrect answers.

3. Lean Construction in Education

The following paragraph show the results of the survey divided into academic levels of Ph.D., M.Sc. and B.Sc. The findings are shortly comment, and later discussed in comparison to lean integration in practice.

3.1 PhD programs

All doctoral schools in Denmark within fields of technical, science and social science were identified and included. 10 doctoral schools obeyed these criteria. Findings are illustrated in table. 1.

Table 1: Lean Construction courses at Ph.D.-level at Danish Universities.

<i>Doctoral school and programs</i>	<i>Courses with LC</i>	<i>Data source</i>
<i>The Doctoral School of Engineering, Science, and Medicine at Aalborg University</i>	<i>No courses or course elements with LC theory</i>	<i>Online course catalogue</i>
<i>PhD School of Social Sciences at Aalborg University</i>	<i>No courses or course elements with LC theory</i>	<i>Online course catalogue</i>
<i>Graduate School of Science and Technology at Aarhus University</i>	<i>No courses or course elements with LC theory</i>	<i>Website</i>
<i>Graduate Schools at Aarhus University Business School</i>	<i>No courses or course elements with LC theory</i>	<i>Website</i>
<i>PhD Schools at Copenhagen Business School</i>	<i>No courses or course elements with LC theory</i>	<i>Website</i>
<i>Management in Engineering at DTU</i>	<i>No courses or course elements with LC theory</i>	<i>Online course catalogue</i>
<i>University of Southern Denmark</i>	<i>No relevant doctoral school, hence no courses or course elements with LC</i>	<i>Website</i>

<i>Roskilde University</i>	<i>No relevant doctoral school, hence no courses or course elements with LC</i>	<i>Website</i>
<i>The Danish Doctoral Schools of Architecture & Design</i>	<i>No courses or course elements with LC theory</i>	<i>Website</i>

As table 1 clearly shows, there are no course with lean construction, either as whole courses or as course parts. The authors are though acquainted with Ph.D.-students work with different parts of lean in construction.

3.2 Master (M.Sc.) programs

Danish universities who offer civil engineering, construction management, and architectural studies are included. In total five universities in Denmark is included in the research. The finding on Master level is illustrated in table 2.

Table 2: Lean Construction courses at Master level.

<i>University and programs</i>	<i>Courses name</i>	<i>LC description</i>	<i>Data source</i>
<i>Aalborg University, Cand.Scient.Techn. in construction management</i>	<i>Project management and economics</i>	<i>Introduction to Lean Construction in general, and in depth on LPS. Estimated to 0,25 ECTS. A part of a course.</i>	<i>Online course syllabus and interview with course responsible</i>
<i>Aalborg University, SBI department, Cand.Scient.Techn. in BIM and construction mgmt.</i>	<i>Change management in construction</i>	<i>Introduction to Lean Construction. Estimated to 0,25 ECTS. A part of a course.</i>	<i>Online course description and e-mail correspondence with course responsible</i>
<i>Danish Technical University, M.Sc. in engineering</i>	<i>Project based production (optional course)</i>	<i>Lean Construction as a management concept; implementation and change management. Estimated to 0,25 ECTS. A part of a course.</i>	<i>Online course catalogue and e-mail correspondence with course responsible</i>
<i>Danish Technical University, M.Sc. in engineering</i>	<i>Construction management and planning</i>	<i>LC theory and methods, LPS and PPC, LC in a national planning perspective. Estimated to 0,25 ECTS. A part of a course.</i>	<i>Online course catalogue and e-mail correspondence with course responsible</i>

As table 2 illustrates, only two Danish universities have courses on Master level with Lean Construction elements, namely Danish Technical University and Aalborg University. In both cases, Lean Construction is fitted into larger course on construction management related topics.

3.3 Bachelor programs

In this section both academic bachelor programmes and professional bachelor programmes is included. All Danish Universities and University Colleges offering construction related programmes

are included. Hence this part includes 5 universities and 7 university colleges. The finding on Bachelor level is illustrated in table 3.

Table 3: Lean Construction courses at Bachelor level.

<i>University and programs</i>	<i>Courses name</i>	<i>LC description</i>	<i>Data source</i>
<i>Aarhus University, B.Sc.Eng in Civil and Structural Engineering</i>	<i>Building processes</i>	<i>Introduction to lean construction, planning and LPS. Estimated to 0,5ECTS. A part of a course.</i>	<i>Interview with course responsible</i>
<i>Copenhagen University College in Engineering, B.Sc.ACTM¹</i>	<i>Construction Management</i>	<i>Introduction to lean construction, planning and LPS. Estimated to 0,5ECTS. A part of a course.</i>	<i>Online course descriptions and e-mail correspondence with course responsible.</i>
<i>Copenhagen University College in Engineering, B.Sc.ACTM</i>	<i>Construction Planning and Cooperation</i>	<i>Development of Process plans. Estimated to 0,1 ECTS, and a part of a course.</i>	<i>Online course descriptions and e-mail correspondence with course responsible.</i>
<i>Danish Technical University, B.Sc.Eng.</i>	<i>Planning and management of Construction</i>	<i>Planning of time and logistics in relation to lean principles. Estimated to 0,4 ECTS and a part of a course.</i>	<i>Online course catalogues and e-mail correspondence with course responsible.</i>
<i>University College of Northern Denmark, B.Sc.ACTM</i>	<i>LC is integrated throughout the education, and small pieces is applied in each semester</i>	<i>Introduction to LC, LPS, Value for client and Lean Design. Estimated to 1, 0 ECTS, small parts in several courses</i>	<i>E-mail correspondence with course responsible.</i>
<i>VIA University College, B.Sc.Eng.</i>	<i>Production planning</i>	<i>Half of a course is assigned LC. LC in general, LC principles, LC tools, LPS, PPC, etc Estimated to 2,0 ECTS, and part of a course</i>	<i>E-mail correspondence with course responsible.</i>
<i>University of Southern Denmark, B.Sc.Eng.</i>	<i>Construction Management (optional course)</i>	<i>Introduction to Lean Construction. Estimated to 0,25 ECTS, and a part of a course.</i>	<i>Online course catalogue and e-mail correspondence with course responsible.</i>
<i>Aalborg University, B.Sc. in Civil Engineering.</i>	<i>Project management and economics</i>	<i>Introduction to Lean Construction in general, and in depth on LPS. Estimated to 0,25 ECTS. A part of a course.</i>	<i>Online course syllabus and interview with course responsible</i>

Table 3 illustrates that Lean Construction is well rooted on Bachelor level. Most of the programmes have an introduction to Lean Construction principles. Only one educational institution has integrated Lean Construction throughout several semesters. University College of Northern Denmark, have split Lean Construction into small pieces and provides on piece in the puzzle for each semester. At Danish Technical University, students can have more than one course with Lean Construction elements, which should grant them the highest level of Lean Construction education in Denmark.

¹ ACTM is a acronym for Architectural Technology and Construction Management

3.4 Additional results

Many of the interviewed course responsible acknowledged that Lean Construction not is paid sever focus in their programmes, but that it in recently years is an integrated topic taught in relation to Construction Management. They also comment on that many students have great interest I Lean Construction, and therefore seek to involve this topic in their group work and/or in their theses. This tendency is confirmed both by the Danish association of lectures in construction methods and management and by LeanConstructio.DK. The latter has a yearly contest where students can submit theses working with Lean Construction. The submission is not overwhelming, but present.

4. Lean Construction in Practice

One thing is theory and the intended use of Lean Construction, another is the practical application of the system by practitioners. To detect differences between theory and application, a questionnaire was designed. First of all, the questionnaire showed a general lack of knowledge of lean construction. When asked "how does Lean Construction see production" 78.1% did not think transformation, 28.1% did not think value creation, and 18.8% did not think flow as a part of the lean construction view of production. The survey looked more specific into the application of LPS, which is the most applied Lean Construction tool at present. The LPS approach consists of a set of elements, which together ensure a reliable schedule. The questionnaire revealed that LPS is not applied as a complete system. Instead only parts of LPS are applied. Combined with the general lack of knowledge this is considered to be one of the barriers towards a more reliable schedule. The results of the question "which elements of Lean Construction have you applied" can be seen in Table 4 Especially, learning and pulling is rarely applied.

Table 4: Which elements of Lean Construction have you applied?

<i>Element</i>	<i>Respondents (n=)</i>	<i>Percent (n/N *100 =)</i>
<i>Weekly work plan</i>	34	91,9%
<i>Look-ahead plan</i>	32	86,5%
<i>Phase schedule</i>	31	83,8%
<i>Master schedule</i>	30	81,1%
<i>The seven preconditions</i>	25	67,6%
<i>Sequencing (post-it)</i>	20	54,1%
<i>PPC</i>	18	48,6%
<i>Pulling (Just-In-Time delivery of materials)</i>	14	37,8%
<i>Buffering</i>	12	32,4%
<i>Learning (PPC)</i>	11	29,7%
<i>Total (N=)</i>	37	100%

The respondents were also asked if failures in the making ready for conduction process where a consequence of lacking knowledge. These results are illustrated in table 5.

Table 5: Is failure in the making-ready-process caused by lack of knowledge?

	<i>Respondents (n=)</i>	<i>Percent (n/N *100 =)</i>
<i>To a very high degree</i>	4	11,4%
<i>To a high degree</i>	16	45,7%
<i>To some degree</i>	4	11,4%
<i>To a lesser degree</i>	4	11,4%
<i>Not at all</i>	3	8,6%
<i>Do not know</i>	4	11,4%
<i>Total (N=)</i>	35	100%

Lean Construction is based on continuous search of excellence, which implies that learning cycles is an important part of Lean application. At present time, the most applied learning tool in Lean Construction is PPC measures and evaluation of these. Table 6 show respondents trust in PPC measures as learning tool.

Table 6: Do you trust in PPC as learning tool

	<i>Respondents (n=)</i>	<i>Percent (n/N *100 =)</i>
<i>To a very high degree</i>	1	3,0%
<i>To a high degree</i>	11	33,3%
<i>To some degree</i>	11	33,3%
<i>To a lesser degree</i>	6	18,2%
<i>Not at all</i>	1	3,0%
<i>Do not know</i>	3	9,1%
<i>Total (N=)</i>	33	100%

5. Discussion

Since this is national investigation of Danish conditions, some international perspectives is put forward to increase the transferability of the results. No thorough investigation of either LC integration in education or LC implementation in practice do exists. It is also out of scope for this research to carry out such a research, hence the following is only a brief overview on LC worldwide in practice and in education.

5.1 Industry take up of Lean Construction

Lean Construction has in the last 10 years become a worldwide concept. This is verified by the establishment of the International Group for Lean Construction, the European Group for Lean Construction, and many national sister organizations. A non-complete list of countries where Lean Construction is adopted in industry is: USA, UK, Finland, Denmark, Norway, Singapore, Korea, Australia, Brazil, Chile and Peru (Ballard and Howell, 2003). Other reports inform that the take up in some countries has been slow, e.g. Netherlands and Germany (Johansen and Walter, 2007, Common *et al.*, 2000). There are for sure several other countries with rising take up of Lean Construction.

There exists several reports point out different barriers for implementation of Lean Construction. Some of the often mentioned barriers are: Deep resistance to decentralized decision making as proposed by the LPS system (Garnett *et al.*, 1998, Johansen and Walter, 2007). Cultural barriers in general is mentioned in several studies (Alarcón *et al.*, 2002, Alarcón and Diethelm, 2001, Johansen *et al.*, 2004, Johansen and Porter, 2003).

5.2 Lean Construction integration in Engineering Education

Not many reports have looked into how well Lean Construction is integrated in engineering education. It is though clear that there is a “competition” of which domains to teach in at universities. Hyatt (2011) concludes that Lean Construction has the least amount of focus within construction management programs. Johnson and Gunderson (2009) have investigated how well recent AEC trends are taken up in engineering education in the US. They found that only half of the US construction management programs include Lean Construction in curriculum. Compared to this research on Danish conditions, the results is very similar. From debates on CNBR forum it is known that some universities in USA, Germany, Israel, Spain and UK have dedicated courses on Lean Construction. In general the tendency is that Lean Construction is placed as a part of construction management course, which limits learning to introduction to Lean Construction.

Another challenge is that since current implementation progress is weak, a limited amount of valid course material is available within the market place. Integration problems of Lean Construction in education are hence threefold. 1) Competition with other traditional and new construction management disciplines. 2) Limited amount of course material is available 3) Industry implementation and request for Lean Construction is lagging.

6. Conclusion

Lean Construction education is lagging the construction industry’s development and request for lean knowledge. This so for Danish conditions. In an international perspective the trends seem coherent. The application of lean construction in practice reflects that engineering students mainly only receives an introduction to Lean Construction, and especially Last Planner System.

It is advised to increase the research effort in this area in the future. If Lean Construction should fulfil its potential for increased value and productivity, more knowledge needs to transfer to the industry.

This effort should take place in the ordinary education system and not only as worksite learning in after educations. A global agenda on Lean Construction integration in education is proposed appointed, in e.g. International Group for Lean Construction, Associated Schools of Construction or CIB working commissions on engineering education.

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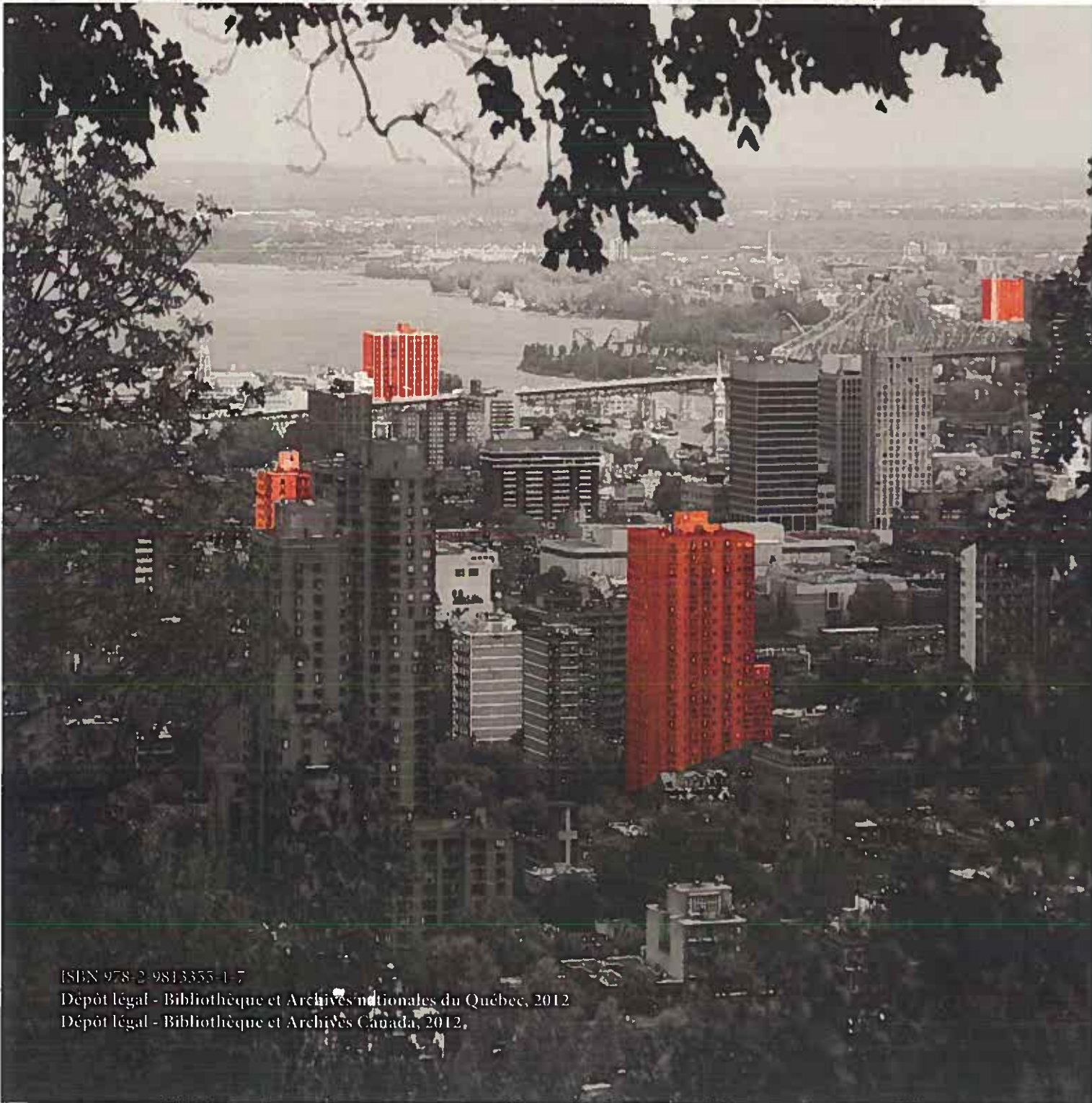
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