

## CANCOM2024 – CANADIAN INTERNATIONAL CONFERENCE ON COMPOSITE MATERIALS COMPOSITES EDUCATION IN CANADA: A SURVEY OF COMPOSITE MATERIALS COURSE OFFERINGS AT CEAB ACCREDITED INSTITUTES

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# ABSTRACT

This paper presents the results of a review of composite materials education in higher education institutes accredited by the Canadian Engineering Accreditation Board (CEAB). Encompassing 46 institutes from all 10 provinces in Canada, data is collected from official course lists provided publicly by each institute. The analysis categorizes course content levels based on the extent of focus on composites (e.g., minor, medium, main focus). Additionally, the paper reports on specific areas of focus, such as mechanics, processing, applications, and material science, the level (undergraduate or graduate) courses are offered, and if there is a laboratory component.

This study aims to shed light on the current landscape of composite materials education in Canada, providing valuable insights for educators, students, and industry professionals. By examining course offerings across accredited institutes, trends, strengths, and potential areas for improvement can be identified and used to prepare the next generation of engineers for successful careers in the composite materials industry.

## **1 INTRODUCTION**

Composite materials play a crucial role in a variety of industries, prompting interest from industry stakeholders, academia, and government entities. A significant amount of growth is expected [1,2]. As the demand for composites continues to grow across various applications, it is essential to evaluate the state of education in this field. Industry anecdotes suggest a knowledge gap and insufficient practical skills in composites within the workforce, hindering progress. The Canadian composites industry, like many others is facing a wave of retirements [3]. A 2021 survey reported that 37% of Canadian composites companies respondents identified 'attracting new (or replacing lost) qualified staff' was their top priority [3]. Many in the composites industry learn on the job and have little to no formal training prior to entering the field. Many engineering undergraduate students are not aware of the career opportunities with composites when they graduate. This paper reports on how common and/or available courses on composite materials are in Canadian higher education institutes.

# 2 DATA COLLECTION AND METHODOLOGY

The Canadian Engineering Accreditation Board (CEAB) accredits undergraduate engineering programs in Canada. Accredited programs provide the academic requirement for licensure as a professional engineering Canada [4]. Their



website shows a list of every institute and program that is accredited [5]. This list was used as a guide to collect data. In total, 46 institutions, with a total of 305 programs were included on this list and included in this study. Figure 1 shows the number of accredited engineering institutions and programs in each province in Canada. Each was included in this study.



Figure 1: Map of Canada showing number of accredited engineering institutions and programs in each province

#### (base map of Canada [6])

The course catalog/calendar for each institution on the list was queried to find reference to the term 'composite' in the course description. Once identified, the course description containing the term was assessed to determine if the term 'composite' referred to fibre/polymer matrix composites or another meaning of the term. Bio-composites, ceramic composites, metal composites and others not related to polymer matrix composites were excluded. One notable exception to this was a course on wood composites. This was included because the course description suggested that the content was very similar to a course on polymer matrix composites and would expose the students to fibre/polymer matrix composites, with transferrable content. Only courses that indicated fibre/polymer matrix composites and/or were vague enough to suggest a range of meanings of the term were implied, as was typically seen in 'introduction to materials' courses. Even though CEAB does not accredit graduate programs, graduate courses from the aforementioned institutions were included. Courses that were identified were categorized according to the focus on composites content, type of content, level (undergraduate or graduate), and if a laboratory component to the course was stated in the course description.

The focus on composites content was categorized with a value of 1, 2, or 3. A value of 1 indicates a small portion of the course touched on composites. A common example of this would be a second-year, 'introduction to engineering materials' course that many programs offer, where a wide variety of materials are introduced and discussed at a high/introductory level. A value of 2 indicates a significant amount of the course contained composites content but was not exclusive to composites. An example of this type of course would be a 'polymers and composite materials' course, where polymers do, in fact relate to composites but the entire focus is not on composites, or perhaps a



course on a specific field or application, for example 'aerospace structures' that includes a large amount on composites. A value of 3 indicates that composites are the main/only focus of the course. A fourth-year technical elective like 'introduction to composite materials' would be a typical example. Courses in this category (3) typically have the term 'composites' in the course title.

Courses were classified into one of the following 11 categories: aerospace, characterization, civil, design, general composites, introduction to materials, manufacturing/processing, marine, mechanics, material selection, or wood composites. The categories were synthesized by examining course descriptions, identifying a category type, then refining once all institutes were surveyed. Courses were then binned into one of these categories. If a course could fit under more than one category, the 'best fit' was used. Each course was put into just one category.

The course level (undergraduate or graduate) was recorded. Reference to a laboratory component in the course description was also recorded. If there was no mention, then 'not stated' was recorded. There is, of course, the possibility that a course could have a laboratory component but not indicate that in the course description.

Data collection was done manually by identifying the course listings of the institute and using the search function to find the word 'composite'. This was performed during January – June 2024, which is during the transition between sessions in many institutes. Some institutes transitioned from their 2023-24 calendar to their 2024-25 calendar during this time. Every attempt to collect accurate data was made, however due to the nature of the searching method, time period, wide variety of data presentation conventions, and languages (English, and French) it is possible that some inaccuracies are present and/or out of date at this point in time. The author would appreciate to hear of any inaccuracies if they are discovered.

# 3 RESULTS

A total of 151 courses that had the term 'composite(s)' (in reference to fibre/polymer matrix composite materials) in the course description were identified. The breakdown of the results will be discussed in detail below. A complete data set is available online in CSV format at: <u>https://compositeskn.org/KPC/A371</u>[7]. The data set includes: institute, course code, course name, level, laboratory component, field/application, and focus on composites.

#### 3.1 Frequency and occurrence of courses

Figure 1Figure 2, left shows the number of institutes that offer courses at an undergraduate level, (only) graduate level, and do not offer a course. The majority of programs, 40 (87%) do offer a course that has the term 'composite(s)' in the course description. However, two of those are only offered at the graduate level, which means that only 38 (83%) are available to undergraduates, when many junior engineers are finding their interests. Six programs do not offer a course with the term 'composite(s)' in the course description.

#### 3.2 Focus on composites

As mentioned above, courses were categorized with a value of 1, 2, or 3 (1 being low, 3 being high) to indicate the focus of composites in a course. These results are shown in Figure 2 (right). Of the 151 courses identified in this study, 81 (or 54%) have a minor focus on composites. The vast majority of these courses are 'introduction to materials' courses commonly offered in second or third year of undergraduate programs. The courses are typically very broad and high level. In many cases, just one or two lectures on composite materials are all that is included in these courses. Fifty-one (or 34%) courses have their main focus on composite materials. These are typically technical



elective courses with a broad introduction to composites. The remaining 19 (or 13%) courses have a medium focus on composites. These generally include courses that focus on a particular application of materials, for example 'aerospace materials' or cover a combination of polymers and composite materials, for example 'introduction to polymer and composite materials'.



Figure 2: Number of programs offering courses at undergraduate level, only graduate level, and no courses (left), and number of courses with composites as their main, medium, and minor focus (right)

#### 3.3 Type of content

Figure 3 shows the number of courses in each category. The largest category is 'introduction to materials', which most institutes offer. This includes nearly every course with a minor focus in composites in the previous subsection. The second largest category is 'general composites'. This includes many of the 'introduction to composite materials' technical electives mentioned in the previous subsection. After that, many courses fall into a specific field, such as civil, aerospace, or marine or a specific aspect of composites like manufacturing/processing, mechanics, or design.



Figure 3: Number of courses in each category



# CANCOM2024 – CANADIAN INTERNATIONAL CONFERENCE ON COMPOSITE MATERIALS **3.4 Course level and laboratory content**

Figure 4 (left) shows the number of courses offered at an undergraduate and graduate level. There are roughly twice as many courses offered at the undergraduate level. A major contributor to the undergraduate courses are the 'introduction to materials' courses (49), which are core to most civil, manufacturing, materials, and mechanical engineering programs. The next largest contributor are the 'general composites' courses (30), which typically include 'introduction to composite materials' technical elective courses.

Figure 4 (right) shows the number of courses offered with either a laboratory session or no mention of one. Courses with no mention may still include a laboratory session, however, it does not state that in the course description. Nearly one third of the courses offered include a laboratory session, while one third do not mention one. Unfortunately, limited/inconsistent information was available regarding the activities students would do in these sessions.



Figure 4: Charts showing course level (left), and courses with a laboratory session (right)

## **4 DISCUSSION AND CONCLUSION**

As we can see from the data presented, almost every one of the 46 institutes does offer at least one course that includes the term 'composite(s)' (with reference to fibre/polymer matrix composite materials) in their course description. Many offered multiple courses at various levels. However, 'composite(s)' did not appear in six institutes' course descriptions. Of these six, five only offered programs that were not likely to be related to composites such as electrical engineering, computer engineering, software engineering, etc. However, one institute offered a mechanical engineering program with no mention of 'composite(s)' in their course descriptions. Two institutes only offered graduate level courses. The significance of this being that students would have to choose to take these courses, which would typically require some a priori knowledge of composite. Some students may go through their entire undergraduate degree with no formal exposure to composite materials. Roughly two thirds of the courses offered were at the undergraduate level, which is encouraging as it makes the subject accessible to a wider audience, at a point in time where students are discovering their interests and career opportunities.

A relatively wide variety of courses that include 'composite(s)' are offered with various levels of focus. Most institutes just touch on it briefly in their 'introduction to engineering materials' courses, however 51 courses that



are entirely about composites were found. These are typically technical electives. Ideally, institutes would offer both types as it would expose students to the subject as part of their mandatory courses, then, if students are interested, they can pursue the subject in their elective courses. The courses that offer a 'medium' focus either present the use of composites in specific applications (ie. aerospace, marine, civil, etc.) or in combination with 'general' polymers. Courses that include a significant amount of composites content in specific applications speak to their significance, and utility in those applications (ie. we simply cannot ignore composites in aerospace any more).

Roughly one third of the courses do offer a laboratory component, however it is not clear what level of focus on composites this entails. Laboratory activities often require significant resources (space/facilities, materials, support staff, etc.), however can significantly benefit student's understanding and connection to the information being taught.

In the future, it would be interesting to repeat this study on a program level (ie. materials engineering, or mechanical engineering programs) rather than just on an institute level. This would provide a more thorough look at which types of engineers are exposed to composites and may be interested in it as a career path. It may also identify programs that could use 'encouragement' from the Canadian composites community to provide more opportunities for their students. This would include ~300 accredited programs in Canada and would be a larger undertaking. Perhaps we will see this at CANCOM 2026.

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