Environm e ntal Influences on Cultural Heritage of Latvia

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1. Introduction

Historical buildings, medieval constructions, monuments and even modern constructions carry or will deliver the archaeological, historic, aesthetic, scientific and/or anthropologic information of our history. The heritage of Latvia as a part of Europe represents the past for many parts and peoples.

Unfortunately, economic growth have been accompanied by industrialisation and urbanisation that have placed enormous pressure in the view of air, water, soil pollution that effect the cultural heritage of Riga, the capital of Latvia Republic. As a consequence some of the most beautiful and historically important monuments coexist with pollution. The effects of pollution could be magnified by climate and therefore it seems to be important to give some details of it, and to investigate the performance of any restoration process in realistic environmental situations.

Latvia provides not only skilled scientists, but also the opportunity to exchange ideas and technologies of restoration in a country with a relatively harsh northern climate.

Notion conservation is defined differently in different countries. Sir Bernard Feilden has defined the name “conservation”:

‘’Conservation may be defined as the dynamic management of change in order to reduce the rate of decay. The cultural scientific and natural heritage must be conserved as authentic documents. Interventions should be limited to actions strictly necessary to insure the techniques and materials used should not impede future treatment or examinations.’’

Thus, using the internationally still recognised *Carta Venezia* - oriented way of looking on conservation, as it is defined by S.B.Feilden, the concept of conservation comprises process which prolong life of cultural property, keeping the objects as much as possible in authentic shape [1].

In Latvia the word ‘’restoration’’ is more popular and is used instead of ‘’conservation’’. With ‘’conservation’’ the last treatment e.g. preventive coating or similar is understood. The meaning ‘’restoration’’ is used also when there is replacement of missing or decayed parts.

2. Air quality in the centre of Riga

Air pollution data collected in the 2000/2001 by the Department of Environment of the Government of Riga show that the concentration of NO_2 in average meteorological conditions during winter months around the Monument to Freedom (the centre of Riga) is in the limits of 65 to 70μg/m^3, but in average meteorological conditions during summer months - 70 to 75 μg/m^3. However during unfavourable meteorological conditions (slow wind, inversion of temperature) the concentration of NO_2 in winter and summer reaches even 140 – 150 μg/m^3 . Such a concentrations should be considered as very high, because the limit value together with tolerance in the year of 2001 is 58 μg/m^3. During the 2002 it will be 56 μg/m^3, while in the 2010 it must reach the concentration of 40 μg/m^3, which will correspond to demands of the EU. For comparison there are data registered not so far from the Monument to Freedom - near the Central Railway Station in the year of 1997 it was 40 μg/m^3, while on the 11th November Embankment in the period of May – September of the year 2000 - 58 μg/m^3. The high concentration of NO_2 in the centre of Riga is a serious problem, which is caused by the increasing amount of cars, frequent traffic jams, and large percentage of used cars.

The estimation of SO_2 concentration was done considering only stationary pollutants as "AIRVIRO" system mathematics models does not foresee emission from transport. The concentration of SO_2 near the Central Railway Station in the year of 1997 was 6,1 μg/m^3 while on the 11th November Embankment in the period of May – September of the year 2000 – 14,3 μg/m^3.

The concentration of SO_2 near the Monument to Freedom during winter and summer months differs significantly. If during the winter months (the period of heating season) it reaches 5 μg/m^3 then in the summer – 3 μg/m^3. During unfavourable meteorological conditions of winter months it reaches even 16 μg/m^3. All above-mentioned pollutant concentration data are calculated for the air at the zone of pedestrian breathing i.e. at the height of 2 m.

3. Deterioration and conservation of stone materials in the Monuments of Latvia

Deterioration of historical monuments is the result of chemical reactions of polluted air, soil and water with the stone material. The crystallisation and hydration of corrosion products results in their expansion causing the degradation of dolomite, limestone, marble, sandstone and other building materials. The stone surface is gradually covered with salts and black crusts containing calcium, magnesium, sodium, potassium sulphates, nitrates etc. and soot, which cracks and peels off. After that stone surface disintegrates into powder the object gradually loses its mechanical strength and artistic form. [2,3]. These processes have been observed on all unique monuments of Latvia.

Riga the capital of Latvian Republic founded in 1201 is rich with it's old cultural heritage mainly located in the eldest part of the town - Old Riga. One of the most beautiful monuments of old city is Riga cathedral or so called Riga Dome Church. The other two chosen for observation and where the scientific investigations and practical stone restoration works are carried out - are not so old but important for the Latvian people as the symbols of their national identity. Those are: Monument to Freedom (1935) and Riga Brethren's Cemetery (1924-1936).

The Monument to Freedom as well as Dome Cathedral are located in the heart of city - in the centre where a lot of traffic go around. Riga Brethren's Cemetery is located a bit away in a green district. There some years ago the super phosphate Factory was in action (closed down in 1965) [4].

In order to reveal how the natural stone monuments of Latvia are effected by air pollution, soluble salts, and water deterioration factors the scientific investigations in the Latvian Academy of Sciences and in the Riga Technical University for more than 14 years have been carried out.

The aim of investigations is to prevent disintegration processes of natural stone materials (limestone, tufa, dolomite, sandstone, old lime mortars etc.) used for constructions of Riga Brethren's Cemetery, Riga Cathedral, Monument to Freedom, Trinity Church in Liepaja, portals and houses of Old Riga, etc.

The objective of investigations is to give an adequate evaluation of the stone damage by chemical. X-ray-phase, DTA and microscopical analyses and to determine the structure, composition, physical and chemical properties and the kind and degree of salination of stones and mortars in order to estimate their quality and to suggest a suitable cleaning and conservation treatment.

3.1 Stone Carving Research

3.1.1 Riga Dome Cathedral

The largest amount of stone carvings of Riga Dome (1211) are in the cross vaulted Cloister passages exposed to weathering conditions and influenced of air pollution. At the arched gallery of Riga Dome, dolomite (Sarema, Estonia) has been used for consoles, capitals and bases. Complete chemical analyses of these stones and corroded surfaces is given in Table 1.

About 400 stone carvings in the cathedral have been preserved through the centuries. Their surfaces had become black and crumbling with time. The process of disintegration was strongly seen in the capitals and bases of columns, which had restored a hundred years ago.

Chemical, X-ray-phase and DTA analysis show the stone carvings of Riga Cathedral have been made of dolomite of different composition and structure. The CaCOs + MgCOs content ranges from 86% to 92%), while the columns have been made of marble. Stone surfaces containing some amount of clay (3 - 5%) and quartz (2 - 3%) have considerably higher degree of corrosion than in bulk [5].

Table 1. Chemical composition of dolomite (Riga Cathedral), travertine (Monument to Freedom) and tufa (Riga Brethren's Cemetery), weight %

Material	Ignition loss at 1000 oC	SiO2	Al2O3	Fe2O3	CaO	MgO	SO3	K2O	Na2O
Dolomite	44,82	4,35	0,78	0,69	28,94	18,90	0,26	0,65	0,87
Black crust	34,34	2,33	2,17	0,50	27,47	11,60	19,20	0,58	-
Powder surface	39,00	5,48	1,65	0,78	27,01	14,20	10,90	0,66	0,25
Travertine	44,36	0,35	0,10	0,09	54, 36	0,42	-	0,06	-
Tufa	44,05	0,68	0,15	0,11	52,80	2,06	0,30	0,10	-
Black crust	23,90	3,26	1,20	0,65	29,02	1,98	38,86	0,43	0,29

Air pollutants are deposited to calcareous stone either in precipitation (wet deposition) or in dry form (dry deposition). Both wet and dry deposition of pollutants can cause significant deterioration of exposed stonework [2].

The basic chemical reaction is that sulphur dioxide, which when combined with atmospheric moisture, produces sulphur acid. That reacts with limestone and dolomite, producing gypsum and magnesium sulphate. In the presence of moisture, these salts penetrate the stone surface, collect soot, begin recrystallization and causes degradation of stone. The corroded stone surfaces display the following degrees of corrosion: I - black, mechanically strong upper layer with the largest sulphate contents (SO_3 - 15 – 36 %); II - the black, upper layer peels off, a powder -like disintegrated dolomite appears (SO_3 18 - 15 %); III the stone carving has lost its artistic form (SO_3 8 %) [5].

Table 2. SO_3 on the Surface of Stone Carvings, Weight %

Stone	SO_3	Corrosion degree
<u>Dolomite</u> (Riga Cathedral)		
Sample 1	12,60	II, III
Sample 2	24,20	I
Sample 3	7,20	III
Travertine (Monument to Freedom)	8,00	Solid surface; grey, slight grey
<u>Tufa</u> (Riga Brethren′s Cemetery)		
Sample 1	38,86	I
Sample 2	11,43	II
Sample 3	8,00	III

The Table 2 shows the amount of SO_3 on the stone surfaces, which corresponds to the degree of corrosion. The relationship between sulphur amount on the surface and it's disintegrated state could be observed for the dolomite objects. The black but still solid crusts on mechanically strong stone surface are characterised by high sulphur contents [5]. The process of disintegration of stone material is more active with presence of such soluble salts as sulphates, chlorides and nitrates of Ca, Mg, K, Na [8].

The crystallisation of these salts requires water and results in their expansion causing the degradation of stone material. By X-ray phase analyses there are determined NaCI, $NaNO_3$, $KNaSO_4$, KNO_3 [7].

3.1.2 Monument to Freedom

Two stone types are used for the Monument to Freedom: grey and reddish granite from Finland and white Italian travertine. In this work more attention was paid to the travertine, as it is type of limestone. The full chemical analyses of this stone material are given in Tab. 1. The chemical corrosion has caused gradual disintegration of travertine carvings, their surfaces are dirty and black. The pores of travertine are filled with sand and soot, thus providing the soil for mass and lichens.

3.1.3 Riga Brethren 's Cemetery

There are several types of stone used in the construction of object: sandstone from Germany, local dolomite, Italian travertine, and local limestone - tufa (Allazi). The most part of the sculptures and the covering blocks of walls are made from the last one. A small amount of organic substances (1.53 %) and Fe_2O_3 (0,11%) are responsible for its yellowish colour. Though very porous however is frost - resistant because the pores never fill up with water more than 90% of the volume [6].

Stone carvings of Riga Cathedral are protected by roofs, but the sculptures in the Brethren's Cemetery and the Monument to Freedom are open - which is an advantage because some of the corrosive agents are partially washed away by rain. The parts less influenced by precipitation's look grave. The stone surface contains about 30% of SO_3.

Analyses show that the main corrosion products are $CaSO_4 \cdot 2H_2O$ (10- 60%), and different chemical compositions, such as $K_3Na(SO_4)_2$, KNO_3, K_2SO_4, Na_2SO_4, $KNaSO_4$, $Na_2SO_4 \cdot 10H_2O$ [7].

Travertine differs from dolomite and tufa as it has higher resistance to the influence of pollution. No surface disintegration was observed for travertine objects and chemical analyses show (Table 2) low or no sulphur content on the surface.

3.2 Conservation of mechanically strong corroded stone carvings

Analysis of published data reveal that reducing of the corrosion products or turning them into soluble combinations is a prime necessity [9]. We chose to desalinise strong carvings by wool - cotton - water poultices. In order to check desalinisation process, we took to determine samples sulphur trioxide content. The chemical analyses show that desalinisation process goes faster during the first 10 days, when sulphur trioxide decreased per 50% [5].

Though this is a labour - intensive method, it is effective: from ten to thirty day's the black surface of the stone turns into white and the amount of sulphur trioxide decreases to harmless level. Unfortunately, as the mechanical strength of the stone reduces it is necessary to conserve the clean stone surfaces through treatment with lime water or poultices.

3.3 Conservation of Disintegrated Stone Carvings

The Conservation of disintegrated stone is very complicated. As the upper layer is partly lost, these stones are characterised by the second and third stages of corrosion. To conserve such stone carvings we applied hydrolysed ethyl silicate to stick the black crust and the powder layer without changing the water absorption properties of the stone. Next we used Baker's lime method, as it is advised in the publication [10]. In the result the disintegrated, mechanically frail stone surface returned into a monolith. To desalinise the remaining corrosive products, we applied wool - cotton - water poultices.

4. References

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5. Problem oriented institutions of Latvia and funding possibilities

The Institute of Silicate Materials (ISM**)** was formed in 1994 uniting the Department of Silicate Technology and Research Laboratory of Glass and Ceramics. The Institute is one of the main research centres of materials science within the Riga Technical University. The main aim of the research work at ISM is to develop basic technology and the scientific characterisation of silicate materials and high temperature non-metallic materials. ISM research areas: Mineral resources of Latvia and their use; fine ceramics, ceramics building materials, ceramics pigments and coatings for ceramics; inorganic binders; functional glass-like materials – structure, properties and applications; ferroceramics, piezoceramics and electroceramics; sol-gel ceramic materials and coatings; conservation and restoration of stone materials. The research area of conservation and restoration of stone materials is represented by the Centre of Stone Material Conservation and Restoration**.**

The Centre of Stone Materials Conservation and Restoration of the Institute of Silicate Materials was founded in the 1995 summarising the knowledge obtained during researches devoted to the investigation of corrosion processes of stone materials, and practical skills of restoration.

Laboratory facilities available:

The composition and structure of stone materials is investigated with the help of following techniques:

- XRD, DTA
- Petrography
- Flame photometry
- Gravimetric analysis

- Complexometric titration.

Scientific personnel involved:

Dr. Sc. ing. L. Krage

Dr. Sc. ing. I. Vitina

Dr. Sc. ing. O. Baumanis

Dr. Sc. ing. S. Igaune

MSc I. Sidraba

MSc R. Lusis

Students: K. Grinenko

A. Mihalevica

The base of theoretical and practical work of the CRCSM is formed of:

- Principles and standards of international cultural heritage restoration/conservation
- Legal requirements of the Protection Inspection of Cultural Heritage of Latvia
- Fundamental investigations of CRCSM
- Co-operation with colleagues from abroad
- Participation in the International projects

The main areas of activities include:

- Research of stone materials of Latvian monuments
- Evaluation, photo fixation, cartography of cultural heritage monuments
- Analyses of corrosion of stone materials: composition of corroded materials, determination of structure and mechanical properties
- Elaboration of restoration/conservation method's
- Stone repair and masonry grout composition design
- Design of restoration program's, recommendations
- Conservation and restoration of stone materials
- Supervision of restoration activities
- Systematisation of information and literature, elaboration of a database of corrosion and restoration of monuments of Latvia
- Theoretical and practical training of new specialists (bachelors, M.Sc. and doctors)

Funding possibilities are mainly restricted to Grants of Latvian Science Council – in the year of 2001 the total sum obtained was 2000 LVL (about 3300 USD per year). There are also several contracts between CRCSM and the Government of Riga not exceeding several hundreds of USD.

6. Joint Projects

Project just launched: *Bioremediation for Building Restoration of the Urban Stone Heritage in European States (BIOBRUSH)*. Co-ordinating Organisation: University of Portsmouth.

Partner names:

- University of Portsmouth, United Kingdom

- Stiftung Institut für Werkstofftechnik, Germany
- DISTAM – University of Milan, Italy
- Riga Technical University, Latvia
- National Technical University of Athens, Greece
- Syremont (Montedison Group), Italy

BIOBRUSH is a research consortium of experienced scientists, industrialists and end-user conservators formed to study the feasibility of using bioremediation to restore buildings in cities. This innovative approach will select appropriate, safe micro-organisms and delivery systems so that treatment combinations can be tested in the laboratory and then on buildings where performance and risk will be assessed under the different climatic conditions of Northern and Southern Europe.

Project objectives:

1. To investigate bioremediation for conservation of stone and brick in heritage buildings throughout Europe.
2. To use microbes to remove salts by *crust mineral destroying* processes and consolidate by *mineral-forming* biocalcification.
3. To screen, select and test suitable stone materials, safe micro-organisms and practical delivery systems.
4. To carry out performance and durability tests and risk assessment for innovative treatment combinations on stone and brick in the laboratory and then on heritage buildings in European cities and urban environments.
5. To identify the environmental constraints imposed by climate within Europe so that the treatment process can be adapted for use throughout Europe.
6. To work closely with industry and conservators to recommend practical treatment strategies based on bioremediation for conservation practice to protect European cultural heritage.

7. Educational Programmes

7.1 About the Riga Technical University

Riga Technical University (RTU) is the oldest and at present the second largest higher educational institution in Latvia, founded under the name of Riga Polytechnic in 1862. At the present economical situation in Latvia the amount of students willing and able to study different engineering fields has decreased significantly if to compare with the second half of seventies: in 8 faculties there are about 7000 regular, 1500 corresponding and 150 doctoral students. The present rector (chancellor) of University – Prof. Ivars Knets.

There are eight faculties in RTU now: Faculty of Architecture, Faculty of Civil Engineering, Faculty of Materials Science and Applied Chemistry, Faculty of Mechanical Engineering, Faculty of Electrical and Power Engineering, Faculty of Computer Science and Computer Engineering, Faculty of Radioengineering and Telecommunication, Faculty of Engineering Economics.

Scientific research is one of the predominant activities at RTU and it is carried out in each faculty, and also in several independent structural units. Research program of RTU covers a broad spectrum from the natural sciences to all areas of engineering and technologies. It also includes architecture, engineering, economics, ergonomics and environmental engineering. RTU scientists are widely involved in different international projects financially supported by European Union (TEMPUS, COPERNICUS, PECO, LIFE, EUREKA) and International Science Foundation. There are also many joint projects with partner universities of different countries (Denmark, Finland, Germany, Italy, Norway, Russia, Spain, Sweden, Ukraine, United Kingdom, United States and another) supported by these universities or local foundations.

7.2 Faculty of Materials Science and Applied Chemistry

There are several departments (13) within the Faculty of Materials Science and Applied Chemistry – Organic Chemistry, Material Sciences, Institute of Polymer Materials, Institute of Silicate Materials etc.

Awareness of the critical situation in preservation of cultural heritage, initiative of some individuals, a small number of specialists as well as activities of conservators/restorers all over the world were the factors advancing the idea of starting education and training of conservation/ restoration (C/R) specialists in Latvia.

In reply to the request of Latvian libraries, museums and archives in September, 1990 an academic group of students in conservation/restoration chemistry and technology was formed for the first time at the Faculty of Chemical Technology (now – Faculty of Materials Science and Applied Chemistry) (FMSAC) at the Riga Technical University (RTU). Beginning with autumn 1996, alongside with engineer′s programme, a master′s degree programme was introduced for logical continuation of specialisation studies after acquisition of bachelor′s degree.

Now, starting a new century and millennium, 10 years have gone since the specialisation was introduced. During this period 5 student groups have graduated from the Faculty, in total 43 students, it is 65% from those who started as the first year students.

Transformation of degree programmes during this period was mainly connected with transition from the standard 5 year study programme to ones conformable to Europe, that is, introduction of credit units, formation of study courses register, bachelor′s, engineer′s and master′s degree programmes when it was necessary to find a compromise between general demands advanced to Latvian Universities, those defined by the Senate of the RTU, Council of the FMSAC, taking into account also interests of Latvian museums, libraries, archives, and other institutions.

With an aim to prepare all-round specialists, particularly for potential conservators/restorers in smaller museums, libraries and archives, wood, paper, textiles, leather, metal, natural stone and ceramics, glass, porcelain were chosen as specialisation directions. A model of close collaboration between the Faculty and specialist employers was put in the basis of students′ education and training, accentuating academic studies at the FMSAC, but acquiring practical skills in the restoration centres and laboratories of libraries, museums and archives during 3 weeks long summer practice. It is necessary to emphasise that degree programmes in conservation/restoration chemistry and technology were formed on the basis of chemistry and chemical technology of the Faculty, discarding a part of technical and technological subjects and introducing instead of them cultural and historical courses as well as those associated with students′ specialisation, simultaneously taking into account the education system of the RTU, appointed compulsory subjects, the number of credit units and other demands.

Lecture courses, incorporated in the programmes, conditionally could be subdivided into 4 groups: the first group contains basic subjects, such as mathematics, physics, a full spectrum of chemistry courses, compulsory for all students of the Faculty, the second - history of civilisation and courses introducing in conservation/restoration art and science, the third - materials for conservation and restoration, methods of investigation and identification, the fourth - material science courses of 7 possible specialisation directions. Such a structure of degree programmes gives students a possibility to acquire the basic courses of chemistry, partially of chemical technology and material science, opening a broader access to labour market.

If from the very beginning of the specialisation an academic group of conservation/restoration students was formed starting with the first year, than now it is done finishing the first year studies. Such changes together with decrease of bachelor′s study time to 3 years, as well as unsolved financial problems of education and training have driven to substitution of summer practice with practical work all over the academic year.

Today conservation/restoration students have access to bachelor′s, engineer′s and master′s programmes, procuring degree of bachelor in chemistry, qualification - engineer or academic degree - master of chemistry in conservation and restoration. As table I shows during 10 years study programmes have changed 4 times. Unfortunately these changes have not given desirable results in the improvement of the study process. It is very possible that in the near future there will be a transition to 4 years long bachelors′ study time, decreasing the following engineer′s or master′s degree programmes by one year.

Table 3. Degree programmes and their structure for specialisation conservation and restoration chemistry and technology.

No.	Academic years	Degree programmes	Study time, years
1.	1990./91.	engineer′s	5.0
2.	1991./92. 1994./95.	bachelor′s engineer′s (after bachelor′s studies)	3.5 4 (3.5+0.5)
3.	1991./92. 1997./98. 1997./98/	bachelor′s engineer′s master′s	3.5 5.0 (3.5+1.5) 6.0 (3.5+2.5)
4.	1996./97. 1999./2000. 1999./2000.	bachelor′s engineer′s master′s	3.0 (3.0+2.0) 6.0 (3.0+3.0)

Remarkable decrease of the number of enrolled students in the last few years is one of the principal problems for further existence and development of the Faculty and the specialisation as the number of students in it is limited.

In such conditions on the one hand there is a greater possibility to work in close contact with students, even individually. On the other hand just from the number of students in the Faculty salaries of the teaching staff and assignment of other resources depend.

The second problem is connected with the advanced age of the teaching staff and research workers, but mainly with further inheritance of their knowledge as young and capable people do not stay at the Faculty nor start working in museums, libraries and archives because material guaranty does not satisfy them. This is the reason why more than one lecture course is excluded from the study programmes, although they are necessary or desirable. It cannot be utterly attributed to the graduates of conservation/restoration specialisation, some of which are already taking the leading positions in museums, libraries and archives and have expressed desire to participate in the training process.

Third, material conditions of students must also be taken into account, as they are not satisfactory for all. Part of students is forced to work losing a possibility of full value studies. Of course, the best version is if the job is connected with further specialisation.

Social credit of students, which today is 35 Ls. per month does not solve this problem. From the point of view of Latvian Students Union means of subsistence of students must be about 115 Ls per month. To the same extent actual is question about student's tuition fee. The Union thinks that direct state subsidiaries must be increased 3 times (to 1.8% from the national income).

The fourth problem is unsatisfactory level of knowledge of applicants after finishing the secondary schools and unconsidered teaching programmes. For example, in some of the middle schools physics and chemistry are subjects of free choice, but at the Faculty they are among compulsory study courses. Just these subjects are often one of the reasons why part of students cannot finish the first year studies.

As the specialisation is interprofessional and multidisciplinary more than 10 lecturers from other Universities, research institutes, museums, libraries and archives, not including practice and qualification work supervisors, are involved in the education and training process. It leads to the complication of planning lectures, practical and laboratory work, increase of study expenses and decreases uniformity of the training process.

If academic education of students in general is ensured today, that cannot be entirely assigned to laboratory and practical work carried out at the Faculty. Not in all lecture courses the necessary proportion between hours of lectures, practical and laboratory work is kept. Anyway for the last two positions the number of hours must be greater. Acquiring of practical skills in conservation/restoration is more complicated and still remains the main problem of the training process and incorporates such factors as:

Practical training bases and the number of working places their, equipment, supply with instruments and tools, chemicals and materials. They are gradually formed in the restoration centres and laboratories of the Latvian History Museum, Latvian National Library, Riga History and Navigation Museum as well as at the Central Microphotocoping and Documents Restoration Laboratory of the Latvian archives system, Scientific Research Laboratory of the Conservation and Restoration of Stone Materials, established in 1995 at the Silicate Materials Institute of the FMSAC. Nevertheless for their normal functioning much must be done in the future from all aspects.

7.3 Involvement of professional conservation/restoration specialists in the theoretical and practical training of students

It is very important to wish, to be able and to know how to work with students, which is a very time- and labour-consuming process. Professional conservators/restorers do not have or have a minimum experience in pedagogy and work with students, but academic staff - in practical conservation/restoration.

7.4 Financial guaranty

Organisation and arrangement of students′ practical training bases, remuneration of lecturers, practical and qualification work supervisors are connected with investments and consumption of larger or smaller funds, which are very restricted. To find them is a common task of the Faculty and employers of the specialists. The same relates to the provision of studies with lecturers, improvement of syllabus and curricula, acquisition of books and journals etc. There is a range of important and necessary study courses which still are not included in the degree programmes as in Latvia there are not specialists in this field. To invite lecturers from abroad or find people who would like to prepare such courses is not possible for one and the same reason. It must be taken into account that education and training of conservation/restoration specialisation students is specific and expensive and differs from other traditional specialisation's of the Faculty.

7.5 Co-ordination *of the study process and* other arrangements, information

This aspect incorporates collaboration between the teaching and research staff inside the University, with professional conservators/restorers, scientists of different research institutes and companies, united by conservation/ restoration of cultural heritage. There must be a person in the system of museums, libraries and archives who can co-ordinate the practical training process, participate in decision making as well as in solution of questions connected with improvement of study programmes and finances.

Along with education and training, research work, as an intermediate stage between the other two must take a remarkable place in the study programmes. Up to now investigations in the field of cultural heritage conservation/restoration are poorly developed in both the conservation/ restoration centres and laboratories, and in the FMSAC, other Universities and institutes. Besides research work is not always connected with needs and actual problems of conservation/restoration. It is a very essential drawback, which remarkably decreases effectiveness of studies. For the time being academic studies and practical training prevail in the study process while research work has a case disposition.

At the disposal of teachers and students there is a very restricted number of textbooks, scientific and technical literature as well as periodical issues. In the main libraries of Riga at best there is only one copy, but to buy or to pay for access to databases is quite expensive at the moment. Nevertheless it is necessary to note that the situation is slowly improving.

To improve the quality of studies more attention must be paid to collaboration with other Universities. This position has been very weak up to now. Starting with the academic year 1999/2000 broader possibility opens for the specialisation students to study abroad. The ERASMUS programme, we hope, will become a stimulating factor for further collaboration at all levels. Unfortunately also in this position it is difficult for us to be equivalent partners.

For foreseeing the further development of conservation/restoration specialisation it is useful to look at material groups, which the students have chosen as lecture courses and qualification work directions. As table III testifies students take greater interest in conservation/restoration of wood, metal and natural stone, but themes of qualification work are more connected with natural stone, paper and metal conservation/restoration. Just these directions of the specialisation are more provided with specialists and bases for practical training.

According to statistics from those starting the first year, bachelor′s degree has been got by about 65%, engineer′s - 27%, but master′s - 29% of the students. From the bachelor′s 27% are working in the field of conservation/restoration, 12.5% in chemistry and 21% in other branches. From the engineer′s 47, 20 and 33%, but from the master′s 64, 29 and 7% are working correspondingly the above mentioned directions, it means that with increasing of conservators/restorers qualification, more and more of them are working in the specialisation.

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Appendix

RIGA TECHNICAL UNIVERSITY
Faculty of Materials Science and Applied Chemistry
Institute of Polymer Materials
Materials Science Professor Group

MASTER PROGRAM

Profile: *Chemistry*
Program of RTU: *Chemistry*
Direction: *Conservation and Restoration*
Level of studies: *Master program*
Nominal study time: *3 years*
Amount of studies: *120 credit points*
Previous education: *Bachelor of chemistry in chemical technology, Bachelor of chemistry*
Designation: *Master of chemistry with specialisation on conservation and restoration*

Code of program ĶMĶ6
Beginning with academic year 1999/2000

Code	Study course	CP	CF	Semester I (aut.)	II (spr.)	III (aut.)	IV (spr.)	V (aut.)	VI (spr.)	L/P/LA
	A. COMPULSORY COURSES	**32**		**10**	**11**	**11**				
	Profile	13		7	6	2				
ĶPI 419	Chemistry and Technology of Polymer Materials	3	E	3						2/0/1
ĶST 551	Chemistry and Technology of Silicate Materials	3	E	3						2/0/1
ĶVT 410	Planning of Experiments and Data Treatment	2	I		2					1/0/1
ĶPI 420	Material Ageing and Protection	2	E		2					2/0/0
ĶOĶ 427	Physical and Chemical Investigation Methods	2	I			2				1/1/0
IDA 117	Fundamentals of Labour Protection	1	I	1						1/0/0
	Program	**2**			**2**					
ĶST 559	Crystallography and Crystal Chemistry	2	E		2					2/0/0
	Direction	17		3	5	9				
ĶST 545	The Theory and Practice of Conservation/Restoration	3	E	3						1.5/1.5/0
Code	Study course	CP	CF	Semester I (aut.)	II (spr.)	III (aut.)	IV (spr.)	V (aut.)	VI (spr.)	L/P/LA
ĶPĶ 435	Pigments and Dyes	3	E		3					2/0/1
ĶPĶ 549	Conservation/Restoration of Archaeological Objects	2	I		2					1/1/0
ĶPI 430	Bio-corrosion	4	E			4				2/0/2
ĶST 569	The Methods in Studding Materials	3	E			3				2/1/0
ĶPĶ 436	Legal Basis of Cultural Heritage Protection	2	E			2				2/0/0
	B. ELECTIVE COURSES	**48**		**7**	**7**	**9**	**12**	**13**		
	Program and direction	30		5	5	5	10	5		
ĶPĶ 315	Leather - Material Science	5	E							2/1/2
ĶST 572	Natural Stone - Study of Materials	5	E							2/0/3
ĶPI 427	Wood - Material Science	5	E							3/0/2
ĶNF 401	Metallic Chemistry (spring)	5	E							2/1/2
ĶPI 428	Paper - Material Science	5	E							3/0/2
ĶST 571	Glass, Ceramics, Porcelain - Material Science	5	E							2/1/2
ĶPI 429	Textiles - Material Science	5	E							2/0/3
ĶPI 431	Conservation of Textiles	5	E							2/0/3
ĶPI 505	Research Work in Restoration	5	D				5			2/3/0
ĶNF 505	Scientific Research in Inorganic Chemistry	5	D				5			1/3/1
ĶNF 504	Scientific Seminars	3	D				5			0/3/0

	Languages	6					2	4		
HVD 409	English Language	6	I,E				2	4		0/8/0
HVD 410	German Language	6	I,E				2	4		0/8/0
HVD 411	French Language	6	I,E				2	4		0/8/0
	Humanitarian/Social	4		2		2				
HSP 488	Business Sociology	2	I							1/1/0
HSP 430	Social Psychology	2	I							1/1/0
HSP 483	Industrial Relations	2	I							1/1/0
Code	Study course	CP	CF	Semester						L/P/LA
				I (aut.)	II (spr.)	III (aut.)	IV (spr.)	V (aut.)	VI (spr.)	
HFL 432	Ethics	2	I							1/1/0
HFL 438	Europe Classical Philosophy	2	I							1/1/0
HFL 433	Presentation Skills	2	I							1/1/0
	Economics and Management	4			2	2				
IRU 116	Market Organisation and Management	2	E							2/2/0
IUV 414	Civil Rights	2	E							2/1/1
IET 527	Theory of Economics	2	I							1/1/0
IRO 417	Technical and Economical Analysis of Economic Activity (autumn)	2	I							2/1/1
IRO 421	Management Organisation at Enterprise	2	I,D							2/1/0
IRO 422	Market Analysis and Strategy of Marketing	2	I,D							2/0/0
	Pedagogy	4						4		
HSP 484	Psychology (for masters)	2	E					2		1/1/0
HSP 446	Pedagogy (for masters)	2	E					2		1/1/0
HSP 485	Contiguity Psychology	2	E					2		1/1/0
	C. OPTIONAL COURSES (recommended)	**12**		**3**	**2**		**4**	**3**		
ĶST 570	Practical Photography and Photo fixation	2	I				2			1/0.5/0.5
ĶST 573	Destruction and Durability of Inorganic Building Materials	2	E							1/1/0
ĶPĶ 554	Fundamentals of Documents Restoration	2	I			2				1/1/0
ĶST 467	Stone Decorative Materials	2	I							1/0/1
ĶST 472	Inorganic Binding Materials	2	I							1/0/1
ĶPĶ 525	Polymer Coatings, Lacquers and Paints	2	I							1/0/1
ĶPĶ 526	Resins for Coatings	2	I							1/0/1
ĶPĶ 527	Selected Topics of Textile Material Science	2	I							1/0/1
ĶST 438	Glass	2	I							1/0/1
Code	Study course	CP	CF	Semester						L/P/LA
				I (aut.)	II (spr.)	III (aut.)	IV (spr.)	V (aut.)	VI (spr.)	
ĶST 444	Ceramic	2	I							1/0/1
ĶST 479	Special Cements	2	I							1/0/1
ĶPĶ 531	Restoration of Coatings	2	I							1/1/0
ĶPĶ 553	Ancient Materials and Technologies	2	I							1/1/0
ĶPI 433	Finishing of Fibre Materials	2	I							
ĶPI 418.1	Conservation and Restoration of Organic Materials	4	E,D							2/1/1
ĶPĶ 551.1	Special Course of Material Science and Conservation/Restoration of Organic Materials	3	E,D							1.5/1.5/0
ĶST 489	Mineralogy and Petrography	3	E							1/0.5/2.5
ĶPĶ 555	Artistic Aspects of Books	2	I							1/1/0
004	**D. PRACTICE/PRACTICAL WORK**	**8**	**D**				**4**	**4**		
002	**E. MASTER THESIS**	**20**							**20**	
	IN TOTAL	120		20	20	20	20	20	20	

Relevant publications

[1] Lusis R., Krage L., Vitina I. The Influence of air Pollution on the Monuments of Latvia. Critical Reviews in Analytical Chemistry, 28 (2), 1998: 113 - 117.

[2] Krage L., Lusis R., Bajare D., Igaune S, Vitina I. Chemical Deterioration and Conservation of Stone Materials in the Monuments of Latvia. Silikatu technologia, Kauno Technologijos Universitetas. Kaunas, "Teclinologija", 21.-23.04.1998:17-23.

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[13] Lusis R., Gripenko K., Vitina I., Igaune S., Sidraba I. Akmens materialu ekologiska sabruksana Rigas Doma kapituizale, EcoBalt-2000, Riga 2000 26-27 maijs Starpt. konf. tezes, 108-109.

[14] Igaune S., Lagzdina S.E., Vitina I., Setina J. Effect of various coatings on carbonation and sulfation of concrete. Vancouver, Canada June, 2001 (in press).

[15] Lagzdins E. Investigation of alkali metals alkyl(acryl) silanolates complexes with various metals and their application. Scientific Israel-Technological Advantages 2000. Vol. 2. No 2, 21-32.

[16] Vitina I., Igaune I., Setina J., Lagzdins E. Corrosion and protection problems of bridges in Riga. Abstracts of 7th International conference Modern Building Materials, Structures and Technique Vilnius, "Technika" 2001, CD-ROM, 5-10.